

PROCEEDINGS OF THE **83RD** MEETING AND SYMPOSIUM



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Virginia Junior Academy of Science Research Symposium and 83rd Annual Meeting

May 3, 2024 - General Session
May 4, 2024 - Student Presentations
May 19, 2024 - Awards Ceremony



A Program of The Virginia Academy of Science

Virtual Research Symposium, hosted by:
The College of William & Mary
Williamsburg, Virginia

Sponsors:
POWER Foundation

VJAS website www.vjas.org

The Virginia Academy of Science

The **Virginia Academy of Science** (VAS) is the fifth largest state, region, or city academy of science in the U.S.; it was founded in 1923 to promote the civic, academic, agricultural, industrial, and commercial welfare of the people of Virginia. Exemplary programs have included Flora of Richmond and Vicinity, Published, 1930, the first comprehensive multidisciplinary studies of the James River Basin and the Great Dismal Swamp, volunteer research assistance to Virginia in the instance of the kepone pollution disaster, and leadership in establishing the Science Museum of Virginia.

Fall Undergraduate Research Meeting:

The focus of this meeting is support of undergraduate student research. Specific details about the 2024 Fall Undergraduate Research Meeting, including the location and date will be made available on the VAS website (www.vacadsci.org) during the summer.

The Virginia Junior Academy of Science

VJAS is a national model for the new and renewing state junior academies and has been ranked among the top three in the nation for over two decades. Through VJAS and other programs, VAS annually reaches over 40,000 Virginia middle and high school students. Hundreds of volunteers make it possible for Virginia secondary students to experience these activities.

The College of William & Mary

The Virginia Academy of Science and the Virginia Junior Academy of Science express their sincere appreciation to The College of William & Mary for the generous support in providing web conferencing meeting rooms and services.

POWER Foundation

The POWER Foundation aims to make the world a better place by inspiring, nurturing and empowering future generations of problem solvers.

Formed in 2013 by [POWER Engineers, Inc.](#) the POWER Foundation is a 501(c)(3) organization dedicated to supporting science, technology, engineering, arts and math education (STEAM) by working with organizations that are building success in our local communities.

The Foundation is proud to sponsor the Virginia Junior Academy of Science and to work with VJAS to help students develop the skills they'll need for successful careers as scientists, engineers, and mathematicians.

The **Virginia Academy of Science** and The **Virginia Junior Academy of Science** notes with appreciation the contribution and support of hundreds of individuals and dozens of organizations to the success of this year's Research Symposium and Annual Meeting.

To Create an Endowment or Make a Donation, please contact Philip M. Sheridan, Executive Officer, Virginia Academy of Science, at psheridan@vacadsci.org or 804-864-1451.

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VJAS Committee Chair's Welcome

Dear Virginia Junior Academy of Science participants,

On behalf of the Virginia Junior Academy of Science Team and Committee, I would like to extend the warmest welcome to each and every one to the 83rd Virginia Junior Academy of Science (VJAS) Annual Meeting and Research Symposium. Although we are not able to meet in person, The College of William & Mary in Williamsburg, Virginia, is hosting our Research Symposium virtually this year.

First, I would like to congratulate our student finalists. Despite the challenges, each one of you strived to conduct the best possible scientific research experiments in a variety of different settings and circumstances. Your valiant and resilient efforts shine through brightly – as a VJAS student finalist, your research papers have been read

thoroughly and were selected by a rigorous panel of evaluators from across the state. This is a great accomplishment, and you should be proud of your research and academic success!

As we commence our virtual Annual Meeting and Research Symposium, I would like to share some thoughts with you. This past year, more so than any others, we have seen a rise in the stake – the importance – of the role science and research plays in our society. Scientists from all corners of the Earth joined together and responded to meet a daunting challenge. We have acted as one to address a global crisis that discriminates against none.

This atmosphere of cooperation and working together as collaborators, and not necessarily viewing each other as competitors all the time, is something we scientists need to continue promoting. Yes, there is a balance – but our society will greatly benefit, and the frontiers of knowledge further breached into new territories faster if we work together more often. Therefore, I would encourage you to view each other during this virtual Research Symposium as future collaborators and colleagues, partners of the future, rather than as competitors.

As you move onward into your collegiate and professional careers, I understand that some of you will continue the path of a scientist, but just as many will choose different routes in medicine, teaching, politics, and so on. What we hope to convey at this year's Annual Meeting is that no matter which career route you choose, your fundamental understanding of science and how research is conducted to bring progress, will be invaluable and become a lifelong foundation. And remember, you can always be an advocate in promoting science and research, wherever you are.

In closing, I hope the 83rd VJAS virtual Annual Meeting and Research Symposium is an enriching and engaging experience for everyone. Once again, welcome and congratulations on your accomplishments

George W. Jeffers Memorial Lecture
Friday Evening VJAS General Session

Resilient Marine Organisms: Making a living in a tough marine world



Louis Burnett, PhD
Professor Emeritus
College of Charleston, South Carolina

Louis Burnett is a Professor Emeritus at the College of Charleston in South Carolina. He was previously on the faculty at the University of San Diego where he served as department chair. At the College of Charleston, he was chair of the Dept. of Biology and Director of the Grice Marine Laboratory. He is currently the Executive Director of the National Association of Marine Laboratories. His long-time interest in the environmental physiology of animals began at the College of William and Mary under his mentor Dr. Charlotte P. Mangum. He did his Ph.D. at the University of South Carolina at the Baruch Institute under Dr. Winona B. Vernberg. Postdoctoral research took him to Aarhus, Denmark where he studied under Dr. Kjell Johansen. His work on marine animals has focused on the physiology of acid-base regulation, respiration, ionic regulation, and immunology. His latest project is on the fitness of shrimp infected with black gill disease using underwater treadmills.

Middle School Sections

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AH – Animal and Human Sciences - A

First Place

Deen Lateef – The Perils of Plastic Can Phytochemicals Overcome the Effect of Microplastics on the Health of *Daphnia magna* (Water Fleas)?

Louise Benton Middle School

Plastic pollution is a significant environmental concern, with vast amounts of plastic waste accumulating in landfills, oceans, and ecosystems worldwide. Microplastics, resulting from the breakdown of larger plastic items, pose serious threats to aquatic ecosystems and human health. Despite the growing awareness of this issue, effective strategies for mitigating microplastic pollution are limited. The main objectives of this project were: 1) To determine whether microplastic exposure affects the health and lifespan of *Daphnia magna*; and 2) To study whether Okra extract can mitigate this harmful effect of microplastics. **Methods:** This study investigated the effects of microplastic exposure on the health and lifespan of *Daphnia magna* (water flea), a commonly used organism in ecotoxicology research. Additionally, the project explored the potential mitigating effects of okra extract, known for its flocculant properties, on microplastic-induced stress in *Daphnia magna*. Experimental setups involved exposing *Daphnia magna* to distilled water (control), distilled water with microplastics, distilled water with microplastics and okra extract, and distilled water with okra extract alone. Heart rate, as an indicator of physiological stress, and mortality rates were measured after 24 hours of exposure.

Results: *Daphnia magna* exposed to microplastics exhibited significantly higher heart rates compared to the control group, indicating increased physiological stress. Moreover, a higher mortality rate was observed in the group exposed to microplastics alone. However, the addition of okra extract to the microplastic-exposed culture mitigated these adverse effects to some extent, as evidenced by reduced stress levels and improved survival rates. **Conclusions:** These findings suggest that microplastic exposure adversely affects the health and survival of *Daphnia magna*, highlighting the ecological risks associated with microplastic pollution. Importantly, okra extract shows promise as a potential natural solution for mitigating microplastic-induced stress in aquatic organisms. Further research is warranted to explore the efficacy of okra extract and other plant-derived compounds in combating microplastic pollution and protecting aquatic ecosystems.

Second Place

Anushka Misra - How Strong is Your Body's Base?

Gainesville Middle School

Foot arches are known as the base of the human body because they support your body's posture, balance, reduce impact and improve the ability to complete daily life functions efficiently. The abilities of a foot arch depend on the arch type- high, normal, low, and flat. Low and flat arches are caused by weak foot muscles and can cause bad posture, limited mobility, poor body mechanics, pain and discomfort. The purpose of this study was to discover whether there is a co-relationship between activity level and arch type so that people could understand if they should modify their activity levels to achieve a normal arch type to prevent pain and other problems that may arise from a low foot arch in the future. 29 participants of the age 12 and above, were asked to complete an activity level questionnaire based on CDC guidelines and leave a footprint that was later measured for Clarke's angle and classified into an arch type. After running the experiment, data shows that people with low activity level may have a flat (50%), low (33%), or normal arch (17%); people with a normal activity level may have a flat (5%), low (50%), or normal arch (45%); and people with a high activity level have a normal arch (100%) typically. While the data shows higher prevalence of flat feet in low activity group, low arches in normal activity level and a normal arch type among high activity group, a strong co-relationship between activity level on arch type was not found.

Third Place

Ahana Goel – The Effect of Ashoka Extract on *Drosophila melanogaster*

George H Moody Middle School

Ashoka (*Saraca asoca*), commonly known as the Ashoka Tree, a plant belonging to the Detarioideae subfamily of the legume family (Singh, et al. 2023). This phenomenal tree has many medicinal uses. It helps with treating cancer, bacterial infections, heart disease, heals arthritis, reduces stomach ulcers, is beneficial for type two diabetes, is a natural painkiller, and helps reduce depression (Singh, et al., 2023). The common Fruit Fly (*Drosophila melanogaster*) is a species of fly in the family Drosophilidae. The hypothesis is that if 0.75 mL of Ashoka extract is used, then the lifespan of the *Drosophila* will increase. The purpose of this experiment was to see if Ashoka extract could help increase the lifespan of *Drosophila melanogaster*. Six 12-inch jars were labeled. Before the flies had arrived, one teaspoon of Instant *Drosophila* Mix, two teaspoons of water, and 3-4 grams of dry yeast were each placed into the jars to

provide food for the flies. One jar received 0.25 mL Ashoka, 0.5 mL, 0.75 mL, and 1 mL. Once the drosophila had arrived, they had been removed from their container and anesthetized. After anesthetization, the flies were separated into males and females. Each jar had 10 males and 10 females. After they had woken up in their new environments, a UVB bulb was lit up and the flies were kept over it 12 inches away and for 150 seconds. The UVB bulb represented sun rays and provided an added condition for the drosophila. The experimenter observed the flies for 25 days until all the original flies died. The results show that 0.75 mL of Ashoka extract worked best in extending the *Drosophila's* lifespan. The data did support the hypothesis as it was that if 0.75 mL of Ashoka extract was used on the *Drosophila Melanogaster*, then the lifespan of the *Drosophila* would increase the most. If the experimenter were to do this again, then she would conduct the experiment in a more temperature-stable environment.

Devansh Kumar - The Effect of Pharmaceutical Pollution on *Daphnia magna* Heart Rate (BPM)
George H. Moody Middle School

This experiment investigated the effects of pharmaceutical contamination, specifically acetaminophen, ibuprofen, and diphenhydramine, on the cardiac activity of *Daphnia magna*, a common organism used in aquatic ecotoxicological assessments. *Daphnia magna* specimens were exposed to solutions containing these medications to simulate pharmaceutical pollution in aquatic ecosystems. The pharmaceuticals served as independent variables, while the heartbeat frequency of *Daphnia magna*, measured in beats per minute, served as the dependent variable. The experimental setup included four plastic cups, each containing *Daphnia magna* specimens filled with solutions of acetaminophen, ibuprofen, diphenhydramine, and a control group without pharmaceuticals. After an hour-long period, the heart rate of the specimens was recorded. Analysis revealed noticeable differences in cardiac rhythms, with diphenhydramine causing the most significant reduction in heart rate. Diphenhydramine resulted in an average heart rate of 147 beats per minute, while acetaminophen had a less pronounced effect with an average heart rate of 207 beats per minute. Ibuprofen led to mortality in all specimens. These findings underscore the importance of understanding the ecological implications of pharmaceutical contamination on aquatic organisms like *Daphnia magna*. While the hypothesis was not definitively supported, the study provides valuable insights into the potential ecological impacts of pharmaceutical pollution, highlighting the need for further research and strategic interventions to mitigate its effects and protect aquatic ecosystems.

Aarya Karmarkar - The Effect of Light Exposure on the Circadian Rhythm of Crickets

George H. Moody Middle School

The purpose of the experiment was to research the effects of different light intensities on the activities of nocturnal crickets during their period of rest, since crickets possess similar gene clocks as humans. The activity levels were determined by the maximum volume of the chirps, as recorded by an app by the National Institute for Occupational Safety and Health. The materials required as per the research included thirty nocturnal crickets, an aquarium tank, and an LED aquarium light with adjustable brightness and color. The levels of independent variables were based on color and percent of full brightness and were the control, which was no artificial light, and the levels of 20%, 60%, and 100% for all blue, white, and blue-white combinations. By process of randomization, the levels of independent variables were assigned to measurement time slots of fifteen minutes, which would follow an exposure period of either three or five hours for three weeks. The results were derived by comparing the maximum sound levels of the crickets when exposed to each light level. The researcher hypothesized that when the crickets were exposed to light at 100% white light, the crickets would experience a surge in their activity levels. This hypothesis was not supported by the data yielded from the experiment. In the experiment, the crickets were the least vocal when exposed to the most light, though they experienced a steady if not heightened sense of locomotion, which was not measured as per the activity.

Grayson Lile - The Effect of Puzzle Bowls on the Eating Speed of a Canine

Sabot at StonyPoint

The purpose of this study was to determine if a slow-feeding bowl would extend the time that it would take a pug to eat. The research indicated that the slower canine eats, the better it is for the digestive system. The research shows that if a canine eats too fast; it is possible that the canine could choke, cough, or have digestive problems. The canine was timed with a slow feeder to see if it would change the canine's average eating time compared to the average eating time without a regular canine bowl. It was hypothesized that if a canine eats with a slow feeder, it will increase the time spent eating, which is better for the canine's digestive system than eating quickly in an open bowl. The pug that was selected for this study was selected based on the owner's reports about the canine's digestive system and how he digests things. The hypothesis was supported in that the results show a more than 100% increase in the time required for the canine to finish eating. It took more time when he was

eating food out of the slow feeder because it is meant to slow down a canine's eating by providing small obstructions that make the canine work harder to pick up the food with its mouth. Ultimately, it can be recommended that a slow feeder be used to improve the digestive health of canines that eat quickly. This can be recommended because it is not ideal for a canine to choke, cough, or have digestive problems.

AH - Animal and Human Sciences – B

First Place

Alexa Nevarez Carrillo - An Investigation into the Wavelengths of Light Perceived by Axolotl
Sabot at Stony Point

Research says that axolotls can smell but not see very well. Axolotls are a species of amphibian similar to a salamander. Axolotls like dark and muddy areas and typically eat worms. Axolotls are also very sensitive and any form of contamination in an axolotl's water can be fatal. This experiment examines how the wavelength of different colors is perceived by an axolotl. It was hypothesized that colors with a higher wavelength in nanometers would be perceived by the axolotl at a greater distance, and the axolotl would have a quicker reaction time. It was hypothesized that orange, as it has a higher wavelength color, would be perceived earlier. An axolotl is an amphibian that never leaves the water. So, the experiment was conducted outside of the Axolotl's tank through clear aquarium glass. A rolling garment rack with different colored poster boards taped to the highest bar was moved at a constant speed toward the axolotl's tank, and both the distance and the time for the axolotl to perceive the motion of the poster were recorded. The hypothesis of the experiment was supported as the colors with a higher wavelength were perceived earlier and at greater distances. Orange was the color that was perceived in the shortest amount of time (at the greatest distance), while blue took the axolotls the longest to perceive and react.

Second Place

Olivia Niemoller -The Reactions of Cats when Presented with Different Scents
Sabot at Stony Point

Cats have 200 million scent receptors in their noses, while there are only 5

million in humans' noses. This makes their noses much more sensitive. It is important to know if they dislike a smell, as it could deter them from wherever that smell resides. That is why this experiment was conducted. Four different cats were tested by letting the felines smell different objects and comparing the data. It was hypothesized that the cats would mostly like different smells but would still show some similarities. The felines all liked the smell of olive oil and a dog treat, which made sense since those are both either meaty or fatty scents. They also liked catnip which is a well-known cat attracter known to make them playful and sometimes hyper. The cats all disliked the "cinnamon and cedar" candle that was presented to them. It was a very sharp smelling candle which suggests that more sharp and unnatural scents put cats off. The results demonstrate that cats like the same smells when it comes to food-like smells, but like different things when it comes to weirder smells, and they usually dislike sharper scents. The hypothesis was supported because the cats mostly liked different smells but if one had a stronger reaction, they all would have a similar reaction.

Third Place

Rachel Kamil The Ship of Theseus: The Effect of Context on the Human Brain
Ronald Reagan Middle School

When I decided to participate in the science fair, I wanted a unique project, something no-one had thought of doing before. To solve this, I combined two of my favorite topics, psychology and Greek mythology. My objective was to use the Ship of Theseus Paradox to test the effect of context on how the human brain interprets information. To achieve my goal, I decided to use a survey to collect data on my topic. My prediction was that the response of the students I surveyed would have different answers based on the context in the background information. By changing the subject from a boat to a human, I would measure the number of people who answered both questions similarly and those who answered them differently. My hypothesis was not supported by my data. Over 20% of students selected similar answers, almost 100 additional responses.

Sheth Shiven -The Effect of the Location of Oyster Reefs on Lead Accumulation on Oysters
George H. Moody Middle School

Oysters filter water for food, however when they filter the water heavy metals like lead can accumulate inside them. This lead can be a serious threat if

ingested, so we need to ensure our food is safe for consumption. The researcher's hypothesis states that if different sources of oysters are examined for lead, then areas with a greater amount of pollution will have a larger lead content in their oysters. To test the hypothesis, the researcher collected 10 oysters from each level of the independent variable, then opened them to insert lead testing swabs to determine the amount of lead. The researcher's hypothesis was supported, since the James River, a river with notoriously high levels of pollution, had the most amount of lead with a score of 4 out of 5, then was the York River with a score of 3.5, then the Chesapeake Bay with a score of 3, and finally Virginia Beach with a score of 1. While the James River had the most amount of lead, based on other studies the lead doesn't seem to pose much of a threat. The main improvement would be to have access to a mass spectrometer for more accurate results.

CS - Chemical Science – A

First Place

Eve Dodd, Ainsley Davis - The Effect of Different Activators on the Stretch of Slime

Sabot at Stony Point

The purpose of this experiment was to find the average stretch of slime based on the different types of activators. Slime is a non-Newtonian fluid, and an Activator is a substance that you use to activate or make the slime become more viscous. Given that there are many different types of activators that can be used to make slime, it was hypothesized that the activator borax and water would have the longest stretch length and that the baking soda and contact solution would stretch the least amount. This was hypothesized because in the past, when slime was made recreationally by the study's authors, borax and water yielded slime with the most stretch, and the baking soda and contact solution was not known to us, and there was little information available on how effective it is at making stretchy slime. To test the hypothesis on which activators result in the most stretch, different activators were used to make several batches of slime. Then, three different tests were conducted for each activator, and the average stretch length was determined. Pictures were taken of each slime, and an electronic scale was used to find the amount of slime used to stretch for the tests. The final tests concluded that the original hypothesis was supported. The main purpose of this experiment is important because it tells us which activator is best for creating stretchy slimes. This study provides guidance to people making slime and will help ensure that the stretchiest slime will be produced.

Second Place

Aditya Mamidala - The Effects of Different Liquid on Tooth Enamel

Individual

This experiment aligned with fundamental scientific principles governing chemical interactions, offering valuable insights into the mechanisms underpinning dental corrosion. This research contributes to promoting dental health awareness and guiding informed dietary choices. This experiment aimed to test the hypothesis that the pH levels of liquids significantly impact eggshell integrity, reflecting potential consequences for natural teeth. The data supported our hypothesis which was, if Coca Cola is used, then the mass will decrease the most. The procedure consisted of collecting 40 washed and air-dried eggshells. The experimenter then prepared 177 milliliters of Coca Cola, Gatorade, water, and orange juice. Each liquid was poured into one cup, along with one eggshell. This procedure was then repeated ten times. The eggshells were then weighed every two days for ten days. This data was then put in a table. The mean for the weight lost in grams for Coca Cola was 2.06. The mean for the weight lost in grams for orange juice was 1.84. The mean for the weight lost in grams for Gatorade was 1.36. Lastly water was 0 grams for the mean. Comparisons with established research, particularly Karda, Jindal et al.'s (2016) study, revealed consistent findings, reinforcing the broader understanding of the detrimental impact of low pH liquids on dental health. The observed outcomes were elucidated through chemical reactions between acids in the liquids and the calcium compounds in the eggshell, analogous to potential effects on tooth enamel. This experiment not only substantiates the hypothesis regarding the corrosive effects of low pH liquids but also establishes a foundation for future inquiries into nuanced aspects of dental health, advancing our understanding of the intricate relationship between dietary choices and dental well-being.

Third Place

Ajooni Kaur - The Effect of Different Types of Salt on the Amount of Time it Takes for Ice to Melt

Individual

The tons of snowfall that occurs across the nation during the winter can cause several issues. Icy roads lead to millions of accidents and kids as well as parents can't go to school or work. In order to melt the snow faster, the department of transportation pours sodium chloride or rock salt onto the roads. However, several studies have shown that other salts could potentially produce better results, or in other words, help the ice melt faster. Since meteorologists

are predicting that we will have an above average amount of snow this year, testing which salt actually melts ice the fastest could potentially be beneficial during the winter season. In order to find the best results, sodium chloride, magnesium chloride, sodium acetate, and calcium chloride will be tested in the experiment. If calcium chloride is used, then the amount of time it takes for each ice cube to melt will decrease. In order to prepare for the experiment, the researcher made 40 ice cubes which were 20 milliliters of water each. The researcher put 10 grams of sodium chloride onto 10 different ice cubes and started the timer. The steps were repeated for magnesium chloride, sodium acetate, and calcium chloride. The researcher recorded the timings for each ice cube as soon as it was completely melted and wrote down observations as well. The results proved that the researcher's hypothesis was correct since calcium chloride took the least amount of time to melt out of all of the chemicals. Calcium Chloride had an average of 14.14 minutes per ice cube which was significantly faster than the rest of the salts. Sodium chloride took an average of 24.07 minutes per ice cube, sodium chloride took an average of 25.12, and magnesium chloride took an average of 47.04 minutes. Clearly, the department of transportation has been using the wrong salt for the roads, considering that it took the second longest time to melt based on the researcher's data.

Dhruv Ghai - "The Effect of pH Levels on the Removal of Rust from Iron"
George H. Moody Middle School

An experiment on the influence of concentration of pH levels on the amount of iron oxide on commercial Ferrum Nails has been carried out. This project was carried out with rusty nails being subjected to 4 different mediums of different pH levels, in addition to 1 control group. These mediums had values of 2.0, 4.0, 10.0, and 12.0, respectively, each with a concentration of 7.0 oz of each. The amount of rust after being subjected to the pH levels was measured by using a balance to measure the number of grams gained or lost, showing how many grams of rust were either added or subtracted from the iron nails. The post and pre-pH level samples' weight has been analyzed with the help of a balance to detect the amount of rust lost or gained in grams. Experimental results confirm that rusty iron nails immersed in lower pH levels and more acidic substances lose rust faster and more abruptly than rusty iron nails immersed in a higher and more basic pH level. As evidenced by this research, lower pH levels have an excellent resistance toward iron oxide corrosion, this is also proven by the fact that higher pH levels in this experiment caused rust not to stop, but to significantly increase.

Eliza Humphries, Henry Lee - The Effect of Different Conditions on the Erosion of Soccer Balls Measured by Mass
Sabot at Stony Point

The purpose of this experiment is to test how long soccer balls take to decompose. This study will help coaches and athletes know how long a soccer ball will last and when it should be replaced. Initially, three soccer balls were put in different conditions: one was in water, one was inside, and one was outside. Every day, the mass of the balls was measured and recorded in a chart. The balls were massed on an electronic scale in grams. After a few days, the one in the water got water inside from the hole where it was filled with air. This experiment showed how the mass in soccer balls can go up and down throughout the process, mainly based on moisture. The results also indicate that soccer balls can best be cared for by protecting them from moisture when possible and not leaving them outside. It was hypothesized that the ball submerged in water would decompose the most out of the three balls. This hypothesis was not supported as the ball that was outside had the most significant loss in mass. While the ball in water originally had the most significant change in mass, once the water was not a factor, the ball outside had the greatest mass loss, indicating the most decomposition. In conclusion, leaving sports equipment exposed to outside conditions will decompose faster than sports equipment stored inside or in water. To ensure that soccer balls stay in the best condition possible, they should be stored inside when not in use.

Eesha Pellreddy -The Effect of Various Amounts of Octyl Salicylate in Soap Mixtures on the Amount of Ultraviolet Radiation Prevented
George H. Moody Middle School

Soundproof materials are used to prevent sound. The purpose of this experiment was to ascertain which soundproof material was most successful. The hypothesis was if each soundproof material is tested on which helps annihilate sound the most, the acoustic foam board will have the most effective result. The experimenter conducted a series of experiments to get accurate results. Even though the acoustic foam board had an acoustic texture, the thickness of the material also played an important role in this experiment. The results of this experiment did not support the hypothesis. In the hypothesis, it was predicted that the acoustic foam board would have the most effective result. In conclusion, according to the experiment that was conducted, the thickest material will have a better outcome. The experiment revealed that the soundproof curtains were most effective.

Vuaj Kandukuri - The Effect of pH Levels on the Preservation of the *Fragaria x Ananassa*

George H. Moody Middle School

Food waste is a problem worldwide, and researchers have been working on ways to preserve food. The pH level of a liquid surrounding the food can affect its preservation. Most liquids can be classified as acidic, basic, or neutral. The pH level is used to determine whether a liquid is acidic, basic, or neutral. Water, which has a pH of 7, is considered neutral. Any liquid with a pH below 7 is acidic, and any liquid with a pH above 7 is basic or alkaline. PH level can influence microbial growth and impact the rate of spoilage. The experiment was carried out using strawberries to investigate the effect of pH levels on food preservation. The independent variable was the pH level, and the dependent variable was the time it took for mold to grow on the surface of the strawberries. Vinegar, coffee, no liquid, laundry detergent, and bleach were used as the IV levels. The control group, which received no liquid, outperformed the others and was able to preserve the strawberries for 120 hours, while coffee, laundry detergent, vinegar, and bleach preserved the strawberries for 96, 72, 48, and 24 hours, respectively. Mold grows best in pH levels of 5.5 or less because it contains more acidophiles than other types of bacteria. This supports the data as the mold grew faster at a pH level of 4.5. This research has an impact on the food industry and helps reduce food waste by allowing for more effective preservation methods.

CS - Chemical Science - B

First Place

Thomas Park Salt Showdown - The Effect of Different Types of Salt on the Speed of the Rusting Process

Swanson Middle School

My experiment aimed to understand the effect of salt on the rusting process of iron nails. Because rust poses such a threat, where it can lead to structural degradation and increased maintenance costs, understanding the impacts and effects is crucial. My hypothesis aimed to uncover the rusting speeds of iron nails, particularly in environments where saltwater was common. I found that, with my samples, sodium chloride and magnesium sulfate did not speed up the rusting process, which drastically contrasts with my hypothesis and research. My project will act as a step stool for future research and investigations, and allow scientists to better understand interactions between iron, water, and salt. Plus, although my experiment is being conducted on a smaller scale, it will still be able

to replicate the effects of rust on structures, or iron nails. Although my hypothesis was not supported, a single experiment is not enough to fully reap results, so more experiments with different restraints will allow more ideas and research.

Second Place

Esham Mital - Effect of Common Kitchen Food Wastes on Voltage Produced by a Microbial Fuel Cell.

George H. Moody Middle School

Abstract: Food waste has become an increasing concern in the world with organic materials contributing to 24% of the makeup of environmentally damaging landfills. In recent years, microbial fuel cells (MFCs) have emerged as an alternative energy source by converting organic substrates into electricity. This can serve the dual purpose of reduced need for landfills and effective reuse. However, it is not known whether common kitchen wastes (CKWs) can be used to generate electricity in MFCs without adding external agents. We hypothesized that CKWs would produce varying amounts of voltage in a MFC without adding external agents. We constructed three two-chamber MFCs connected via a salt bridge. The CKWs used as substrates were potato, bread and dairy. A substrate homogenate was poured into the anode and the cathode was filled with a salt solution. Carbon brush electrodes connected to copper wires transmitted the current and the voltage generated was recorded using a multimeter. Ten readings were taken over an hour for each MFC daily for a period of four days. A mixed-measures ANOVA showed a statistically significant difference in voltage produced (dFnum 2, dFden 108, $F = 1335.6$, $p < 0.001$) between the three food groups. Therefore, the null hypothesis was rejected in favor of the alternative hypothesis. Further, a multiple level comparison method showed a significant difference in voltage produced by potato and dairy, dairy and bread, and bread and potato. The potato and white bread groups had a steady and low voltage generation over the duration of the experiment. Dairy had a significantly higher voltage production in the first two days. However, there was a steep decline in voltage produced by dairy waste on days three and four. The dairy group likely produced high voltage because of the presence of lactic acid as a substrate which is a more effective fuel source for breakdown by bacteria. However, as the lactic acid supply depleted, the voltage produced declined significantly. Future studies are needed to examine the effect of mixing various substrates and sequences on energy production and bacteria produced.

Third Place

Saharsh Shetty -The Effect of Different Types of Fruit and Sports Drinks on the Electrolyte Replenishment for Athletes

George H. Moody Middle School

Athletes need to replenish their lost energy with electrolytes in sports and fruit drinks. This experiment was conducted to determine which sports or fruit drinks contain the most electrolytes and are more nutritious for athletes. These sports drinks (Gatorade, Powerade, Body Armor) and fruit drinks (apple juice, orange juice, lemonade) were measured for their electrolyte content using a conductance sensor. The experimenter hypothesized that the electrolytes would be higher in sports drinks than in fruit drinks and that individually, Body Armor would have the highest electrolyte content. Also, the nutritional data of each drink was evaluated based on its calories, carbohydrates, sugars, and sodium. After recording data on 3 bar graphs and analyzing the results, the experimenter determined which drink had the most electrolytes. The fruit and sports drinks had an electrolyte content that ranged from 10 to 30 milliamps. Body Armor had the most electrolytes out of all of the drinks with 27.56 milliamps, while orange juice came in second with 19.96 milliamps. Gatorade and apple juice had the least electrolyte content, which was surprising since both drinks are heavily advertised for their hydration. Experimenting and comparing the electrolyte content of lemonade and lemon juice determined that adding water lowers the electrolyte concentration of a mixture. Even though it was unclear which group had the most nutritional value, sports drinks had the highest electrolyte content, so they are the best choice for exhausted athletes!

Third Place

Vihaan Shirodkar -The Effect of Humidity on Metal Rust in Wood

George H. Moody Middle School

Every year, many earthquakes occur all around the world resulting in a multitude of collapsing homes. One of the main parts of these houses are the nails and when they rust, the buildings get even weaker. Therefore, an experiment was conducted to analyze the effect of humidity on metal rust and to make it more applicable, nails were hammered into wood. The hypothesis was if metal is placed in different humidities, then it will rust slower in a lower amount of humidity. For the procedure, the nails were put into a container that had a certain humidity for some days. After that, the rust was wiped off the nails and the change in mass was recorded. The research hypothesis was supported by the data. Because one of the three factors for rust is water and humidity is the amount of water in the air, it was reasonable for the metal to rust in a more

humid environment.

Aditya Purohit -The Effect of the Degree of Photodegradation of Natural and Artificial Light on the Deterioration of *Solanum lycopersicum*
George H. Moody Middle School

Throughout many stages of life, humans have used many techniques for food preservation. This included drying which was efficient and helped preserve food. However, studies have shown that natural/artificial light can spoil food. Therefore, an experiment must be conducted to meet the needs of research towards forms of light-induced processing, the quantification of light, and its effect of photodegradation. The purpose of this experiment was to determine how various intensities of light impact cherry tomatoes. If the *Solanum lycopersicum* is tested under 800 lumens of artificial light, the product will moisture-loss, have less intense light wavelengths, and will have greater fungi growth. Using rubber gloves, ten cherry tomatoes were placed on each paper plate. Two lamps were placed near two of the paper plates, with the diameter of the bases being five inches. Of these two lamps one was provided with 800 lumens and the other with 200 lumens. One of the other paper plates were placed near the blinds and opened in a way, in which one plate would receive 100,000 lumens of light. Lastly, a plate was placed in the dark as a control. The cherry tomatoes were placed for seven days. The highest deterioration was recorded in the tomatoes placed under bright artificial light with moisture loss of 126.82 ml, fungi growth of 0.3 inches, and the luminosity of 42 lumens. In conclusion, the FDA can now construct regulations on the use of artificial light when processing foods to preserve a healthy population.

Sambangi Saanvi -The Effect of Ayurvedic Oils on the Production of VOCs
George H. Moody Middle School

Ayurveda, an herbal, India based medicine practice, is used regularly by citizens in the United States, however it's not regulated as a medical practice by the FDA. This is because there isn't any real significant educational movement promoting the practice, or any proper certifications. However, this could prove to be detrimental for the people treating their ailments with ayurvedic oils. If people are breathing these oils in, it'll especially harm them, and most treatments call for inhalation, like forms of aromatherapy. Unfortunately, VOCs, volatile organic compounds and a form of air pollution, are found in essential oils and can be incredibly harmful when inhaled. In fact, they can permanently affect livers,

kidneys, nervous systems, cause cancers, and interrupt women's menstrual cycles, so it's important that they are treated seriously and immediately. The purpose of this experiment was to test different ayurvedic oils, specifically eucalyptus oil, Saraswati oil, and castor oil, to measure the number of VOCs they produce to assess their toxicity level. Due to the high concentration and nature of eucalyptus oil, it was hypothesized that it would release the most VOCs. To conduct this experiment a diffuser was filled with 120 ml of water and 1.2 ml of eucalyptus oil. Then the TVOC (total VOC) of the inside of the cardboard box was measured with an air quality monitor, before the diffuser was placed inside. After the box was sealed airtight with tape, a timer for 10 minutes was set. After the 10 minutes were up, the box was opened, the diffuser was removed, and the TVOC was measured again, and the increase was recorded. The procedure was repeated 10 times for each of the 3 independent variables. The data was then averaged, with a mean of 1.017 mg/m³ for eucalyptus, 0.699 mg/m³ for Saraswati, and 0.568 for castor oil. Clearly, eucalyptus oil released the most VOCs, but every single independent variable released a high amount of VOC, considering above 0.3 is problematic. The hypothesis was supported, but before any action can be taken, more trials need to be conducted in a far more sterile environment to verify the results.

Juliette Thomas-Irvin -Testing the Effect of Different Dish Soaps on Elephant Toothpaste
Sabot at Stony Point

Elephant Toothpaste is a well-known decomposition reaction where hydrogen peroxide is broken down into water and oxygen gas. Crystallized Potassium Iodide is the catalyst that creates a rapid exothermic reaction resulting in the multiplication of oxygen bubbles. The balanced chemical equation for the reaction is: $2\text{H}_2\text{O}_2 (\text{aq}) \rightarrow$ in the presence of Potassium Iodide $\rightarrow 2\text{H}_2\text{O} (\text{l}) + \text{O}_2 (\text{g})$. For an elephant toothpaste reaction to occur, a carrier such as food coloring and dish soap is commonly used as the reaction becomes visible. The goal of this project was to determine if the type of dish soap changed the outcomes of the experiment when all other ingredients remained constant while the type of dish soap changed. Four different dish soaps were tested to see the effect that they had on the height and temperature of the elephant toothpaste. The dish soaps that were tested were Dawn, Palmolive, Ajax, and Seventh Generation. The hypothesis was that Dawn would react for the longest amount of time and Palmolive would achieve the highest temperature and height, Ajax would perform the most similarly to Palmolive, and Seventh Generation would be the least reactive with the lowest reaction height and temperature. The

hypothesis of the experiment was partially supported as different soaps did affect the outcomes of each experiment, and Palmolive did have the highest temperature and the greatest height. However, Seventh Generation had the longest reaction time. Further studies of the makeup of the dish soaps would be useful in understanding why the outcomes were different based on the dish soap tested.

EE - Ecology and Earth Sciences

First Place

Rebecca Zee -The Effect of Different Fertilizers on Water pH Levels

Individual

Each time a fertilizer is used, run-off carries those fertilizers into waterways. These fertilizers significantly impact water quality by altering the pH levels. Aquatic organisms struggle to survive as their lives are uprooted, and their habitats are destroyed. The goal of this experiment was to find the effect of different fertilizers on water pH levels, and more specifically, to find which of the three main components of fertilizers would have the greatest impact on water pH. Three fertilizers were chosen, each having more of either nitrogen (blood meal), phosphorus (bone meal) or potassium (kelp meal) (independent variable). 8 grams of each of the fertilizers was mixed with 250 millimeters of water, and after 10 minutes, the pH of the mixture was tested (dependent variable). The hypothesis was that the blood meal fertilizer and water mixture would have a pH level the farthest from neutral (7 pH). The results supported the hypothesis because on average, the water mixed with the blood meal fertilizer had a pH farthest from neutral (6.12 pH), compared to the bone meal fertilizer-water mixture (7.45 pH), and the water mixed with the kelp meal fertilizer (7.21 pH). The research and results of this project show that when the goal is to keep the environment healthy, blood meal fertilizer (and nitrogen-based fertilizers in general) should not be used.

Second Place

Erin Jansen - When in Drought... Natural Hydrogels as an Alternative Water Resource to Aid Water Retention in Soil

Individual

Climate change and population growth are major contributors to the world's dwindling water supply. Droughts that affect crop yield and high temperatures that dry out soil put pressure on the already stressed agricultural industry trying to supply food to a growing population. Reducing water usage and waste in

agriculture and providing a more efficient way crops use water to improve yield would have a significant positive environmental and societal impact. Hydrogels, groups of hydrophilic polymers chemically attached to each other, absorb and hold large quantities of water then release it slowly into the soil for use by plants, reducing the amount and frequency of irrigation and decreasing losses to evaporation and runoff. Widely used synthetic hydrogels do not decompose and contain toxic chemicals, making them a poor choice for agricultural use. This experiment examined the absorption capacity, rate of water loss over time, and effect on water retention in soil over time of three types of natural hydrogels. The pure hydroxyethyl cellulose (HEC) hydrogel and the agar + HEC combination hydrogel showed the greatest amount of water absorption (approximately 19% and 18%, respectively) compared to 14% for the pure agar hydrogel. With a slower rate and overall lower percentage of water loss during the 14-day period, the agar + HEC hydrogel demonstrated the greatest resistance to evaporation. All hydrogels improved water retention in soil over the control. The greatest improvement in soil moisture was observed with the HEC hydrogel. The hydrogels containing hydroxyethyl cellulose (HEC), either alone or in combination with agar, outperformed the pure agar hydrogel. This natural polymer exhibits potential as an alternative water source for moisture retention in soil for agricultural use.

Third Place

Samara Habib -The Effect of Fertilizer on Soil pH

George H. Moody Middle School

Many life-threatening diseases and illnesses, such as lead poisoning and itai-itai disease are caused by heavy metals in the soil (Mitra et al., 2022). Heavy metals in soil are absorbed by plants. When these plants are consumed by humans, the heavy metals are also entering the body (Steffan et al., 2017). The pH of soil is one of the factors that determine the bioavailability of these heavy metals in soil (Olaniran et al., 2013). Fertilizers can change the pH of soil because they often contain nitrogen, which decreases soil pH (Ren et al., 2020). The hypothesis for this experiment was that if the Scotts Turf Builder Starter fertilizer is used in soil, then the soil's pH level will have the largest decrease. The independent variables in this experiment were Espoma Garden Lime, Scotts Turf Builder Starter Fertilizer, Expert Gardener All-Purpose Water-Soluble Plant Food, and Ironite Plus 12-10-10. The experiment was set up by adding 147.87 milliliters of potting soil, 59.15 milliliters of fertilizer, and 59.15 milliliters of water in a cup. After five days 59.15 milliliters of water was added to the cup again and a pH test strip was used to check the soil pH. This experiment was

repeated ten times for all the fertilizers and the control group of no fertilizer. The results show that the Espoma fertilizer resulted in the highest average soil pH while Scott's fertilizer resulted in the lowest average soil pH. The hypothesis for this experiment was supported by the results. The Scotts fertilizer was the only fertilizer that resulted in a lower average soil pH than the control group.

Honorable Mention

Kieden Chun, Lucy Reibel - The Effect of Different Types of Pollutants on the Production of Ammonia in Saltwater, Brackish Water, and Freshwater
Sabot at Stony Point

The purpose of this study is to evaluate the water quality of the James River as it changes from freshwater near Hopewell, VA, and increases in salinity as it nears the southern portion of the Chesapeake Bay Watershed, eventually merging with the Atlantic Ocean. This investigation evaluates the amount of ammonia, nitrite, and nitrate in fresh, brackish, and saltwater. The hypothesis for this project was that freshwater would have a higher part per million (ppm) of ammonia and nitrite overall because salt can contribute to the breakdown of some wastes in salt water. Freshwater water samples were collected from the Jordan Point Marina in Hopewell, VA, and the brackish water was collected from Tyler's Beach in Smithfield, VA. The saltwater was made in the lab with a 1.024 specific gravity amount of Instant Ocean Sea Salt in a 1000 ml beaker using spring water. The waters were then tested with the API Freshwater Test Kit. The final results for this experiment indicate a significant difference in the production of nitrite in freshwater than in saltwater. It should be noted that pollutants were added to the saltwater samples. The ammonia and nitrite levels in saltwater were lower when compared to the freshwater collected. This shows that salt in the water can make the water the smallest amount less toxic. This study also indicated that pollution could contribute to ammonia and nitrite levels, especially chemical pollutants like Windex. It was hypothesized that freshwater sampled from the Chesapeake Bay Watershed would have greater amounts of ammonia and nitrite. This hypothesis was supported.

Honorable Mention

Sanjana Nath -The effect of oysters on the turbidity of water

George H. Moody Middle School

Oysters are considered nature's water filter. They can filter up to 1.3 gallons in an hour, which is about 30 gallons of water every day. They are found in brackish water. They can help clear up water and get rid of its turbidity. Currently their numbers have been decreasing in the Chesapeake Bay due to overharvesting, pollution and disease (Reitsma & Murphy, 2017). This has caused pollution to increase in the water. Turbidity is the clarity of water and how clearly you can see in the water. Water is considered turbid if it has plankton and algae within it. Some sources of turbidity include clay, silt, very tiny inorganic and organic matter, algae, dissolved colored organic compounds, plankton and other microscopic organisms. The researcher's hypothesis was, "if there are more oysters in the tank, then there will be less turbidity." This was supported by the experiment. The reason the researcher conducted this experiment was to find out if, when the number of oysters increase, then will the amount of turbidity decrease. Tank four was the clearest after two hours. Tank number 1 had the most turbidity by the end of the two hours. After every thirty minutes the water's turbidity was recorded. At the beginning the first tank was purifying the water quickly, but as time went on it started slowing down. There were two trials, and of the two the second one did better. In the second trial the water got clearer in the fourth tank, than it did in the first trial. The first tank had the least number of oysters but the most amount of turbidity. The second and third tanks had roughly the same amount of turbidity, but the third one had less turbidity, and the second tank had more. In graphs one and two in the results section, it shows how the hypothesis was correct because tank one ended with the most turbidity. The fourth tank consistently had the least amount of turbidity.

Honorable Mention

Hargun Tuteja -The Effect of How Much Water Evaporates on Different Materials

George H. Moody Middle School

This experiment is important because it can implement further research about controlling global warming by limiting the amount of water vapor in the atmosphere, because water vapor amplifies the warming effect. The hypothesis for this experiment is, if water is kept on a sponge, then it will be left with the most amount of water. This is because the bubble-like spaces in the sponges have the ability to hold water. The Independent variable for this experiment was

the different materials used and the dependent variable was that amount of water left on each material after it had been placed under a heat lamp. The levels of the IV were sponge, copper, glass, and wood. There was no control group. To conduct the experiment, water was placed on each of the levels of IV and left under a heat lamp for two hours. After 2 hours, the amount of water left on each material was recorded. This entire experiment was repeated 10 times. The constants of this experiment were the type of water, the place of the experiment, the amount of water, the temperature, and the humidity. The results show that on average, wood was the surface that the most water evaporated from, but sponge was close behind and copper had the least amount of water evaporated from it. The hypothesis was not supported because copper was left with the most amount of water. To improve this experiment for further study, a stronger compressor machine/device should be used, to ensure that all the water in the sponge is emptied out. Before conducting the experiment, an amount of water will be put in all the materials and then emptied out. The amount of water emptied out would be recorded to see how much water would be getting absorbed into the materials and getting stuck, instead of being evaporated. From conducting this extra step, the results of the experiment could be more accurate since there would be a way to know how much water was getting stuck in the materials.

Aarav Saxena -The Effect of Biodegradable Hydrogels on Biodegradability and its Ability to Soak Up Water

George H. Moody Middle School

In the researchers' experiment they made biodegradable hydrogels out of agar and hydroxyethyl cellulose (HEC). These hydrogels help farmers water their crops precisely and save time for the farmers. The researcher tested the hydrogels biodegradability and ability to soak up water. He did this by submerging the hydrogels in water to test how much water they soak up and the researcher set and watered hydrogels out for 5 days to test how much they degrade. The researcher hypothesized that if the researcher uses a 50% mix of agar and a 50% mix of hydroxyethyl cellulose, then the researcher can make a hydrogel that can degrade and soak up water better than the other hydrogels. This was not proven as the hydrogel that degraded the most was the 100% agar hydrogel and the hydrogel that soaked up the most water was 75% HEC and 25% agar. While the researcher does believe that their experiment was done well, they believe that they could have cut down on the wait time during testing.

Avery Hanger -The Differences Between Water Parameters in Small Ponds and the Runoff of Small Ponds

Sabot at Stony Point

This study aimed to investigate the chemical parameters that are used to test water quality. Water pollution significantly affects inland lakes and ponds and the larger aquifer in Richmond, VA. However, it is difficult to identify and test for non-point source pollution. By testing water in two different locations, both from the same source, point source pollution could be identified. More information needs to be provided regarding point source and nonpoint source pollution in smaller ponds and streams. This study examines Young's Pond and its runoff stream in Richmond, Virginia. When starting the experiment, the initial goal was to find ways to test large bodies of water without harming wildlife. Throughout this project, that idea changed to finding out how to test local streams to determine how the area and environment around the body of water affect the quality. A plastic bottle of water was also tested for comparison to ensure that these tests were accurate. It was hypothesized that the water quality would be the same or similar because both bodies of water were connected and less than a mile away from each other. However, that hypothesis was not supported after testing, and the two bodies of water had significant differences. In conclusion, the runoff of Young's Pond, located in Bryan Park in Richmond, VA, was closer to the parameters of bottled water than the runoff of Young's Pond.

Ennis Pol, Sam Padden -The Effect of Construction on Wildlife Populations in Lewis G. Larus Park Over 2 Years

Sabot at Stony Point

The State of Virginia has many natural parks housing many different species, from the *Vulpes vulpes linn* (Red Fox) to the *Haliaeetus leucocephalus* (Bald Eagle), and many more. However, in recent times, especially in the capital city of Richmond, construction has been increasing, even near the protected natural parks. The purpose of this study was to find out if construction that occurred near Lewis G. Larus Park and the surrounding areas in the past year has had a positive, negative, or no effect on the amount of wildlife in the area. This experiment was designed to measure changes in the animal population in the park. Before the experiment was conducted, it was hypothesized that the construction had a negative impact on the amount of wildlife in the park. This includes destroying habitats which can lead to wildlife moving out of the park and onto the roads, potentially leading to more accidents. To conduct this experiment, a wildlife trail camera was attached to a tree, and bait was placed 2

meters from the camera. The camera was set up in 4 different 26-acre quadrants around the area in which the construction had occurred. After 4 - 5 days, the camera was retrieved from the park, and the SD card inside the camera was placed in a Windows Surface Pro laptop with a Micro SD reader, and the images were then downloaded, the animals recorded and then sorted into a raw data chart. These results were then compared to a set of data used as a control group recorded 12 months ago in the same exact area to obtain a final result. The result of the experiment indicates that the construction has indeed had a negative effect on the amount of wildlife in the area, thus, the original hypothesis was supported.

Vihaan Kandula - Effect of the Amount of *Eisenia fetida* on the pH of Soil
George H. Moody Middle School

The pH of soil has been shown to be a very important factor of plant growth and plant health (Pokorny, 2021). There are many pH controllers used in agriculture, such as sulfur, but they have been shown to lead to respiratory issues in children (Ranaan, et al, 2017). Also, sulfur has been shown to affect the environment negatively in many different ways (SCI, 2020). The researcher was trying to find a more natural way of altering soil pH. The researcher chose Earthworms as a natural pH altering agent. Earthworms have been shown to be pH sensitive animals, and they don't like acidic so, Earthworms may change the pH of the soil surrounding them to be more basic (Wu, et al, 2019). Also, places with more earthworms have been shown to have more basic soil, which is another reason the researcher chose earthworms (Fonte, et al, 2023). If 5 Earthworms are placed in the soil, then the pH will be the most basic. To conduct the experiment, the experimenter took 40 plant pots, put two earthworms in the first ten pots, three earthworms in the next ten pots, four earthworms in another ten pots, and five earthworms in the last ten pots. Each increased number of the earthworms of the levels of I.V in this experiment. The experimenter left these earthworms for four weeks, measuring the pH and feeding the earthworms with apples each week. The pot with five earthworms had the most basic pH. The hypothesis was supported in this experiment. The pH of the soil may have changed, because of the pH sensitivity of Earthworms (Wu, et al, 2019). When doing this experiment in the future having a larger test group, hydrating the soil, and making the experiment longer than 4 weeks, then it will lead to more accurate results

ET - Engineering and Technology

First Place

Riya Nimonkar -The Effects of Different Heat Shields on Durability and Heat Over Different Heat Cycles

George H. Moody Middle School

Recently the Artemis II launched into space, and whilst it was a successful mission, it had its setbacks. The main set back being that NASA has ended up wasting a lot of money on the frontal cone or the Orion heat shield (Kruesi22). The purpose of this experiment was to test which heat shields would have the best ability to intake large amounts of heat while still being durable, specifically on a scale equal to space. The experimenter's hypothesis states that if fiberglass, aluminum, gold foil, and aerogel are applied to this experiment, then aerogel's durability and ability to hold heat will be the best over multiple heat cycles. Soon after, the experimenter conducted her experiment (after taking safety precautions). She tested the heat and durability by setting each material through three heat cycles going from 14°C anywhere to 1800°C. After, she would conduct a drop test to see how durable the material was after being heated and hardened. The results of this experiment were slightly different from what the experimenter had originally thought. As expected, the aerogel conducted heat the best; however, fiberglass ended up being the most durable. The experimenter concluded that the experiment was successful but could have been made better if done in a more secure environment such as a lab but also had a better usage of materials.

HB - Human Behavior

Second Place

Vertika Manoj Kumar -The Effect of Stress on Frustration

George H. Moody Middle School

This experiment is designed to help educators understand the complexity of a student's emotions. The toxicity of the environment in our public-school systems has been noted by multiple people, including parents who are expressing concern for their children. In this experiment, there were multiple procedures taken to understand how stress and frustration interconnect. First, all volunteers

were asked to complete pre-surveys which gave them scores that put them into various categories. These categories determined how much stress was placed upon them. Afterward, the volunteers were taken separately into a room where they faced a task that proved to be impossible. Using iron nails, wire, and many other materials, a grid of electromagnets was created. The objective was to create a certain pattern on the grid using paper clips. While the volunteer attempted to complete this task, the experimenter reversed the double pole double-throw switch that was connected to the electromagnets to change the polarity. This made the task impossible and therefore had a result of frustrating the volunteers. The volunteers were recorded while they completed the task, and the experimenter used the recordings to make physical observations. The volunteers were also expected to complete a post-survey for more clarity on their side of the experiment. If students experience less stress and frustration, then they will handle their emotions better. This statement was proved true after the data was collected and examined. Students who received lower scores on the pre-survey measuring their stress levels had less severe outbursts of confusion and more mild and controlled emotions. The hypothesis can also be supported by multiple certified sources that show how the two can impact each other.

Third Place

Vishrut Sathyanarayanan -The Effect of the Color of a Tasteless Liquid on the Perception of its Flavor

George H. Moody Middle School

In the realm of scientific inquiry, as technology progresses and researchers dive deeper and deeper into the workings of the human brain, peculiar phenomenon like the placebo effect and the brain's quirk of detecting non-existent stimuli intrigue us all. Among these curiosities lies taste perception, which is an integral part of human experience often overlooked. The study sets out to explore the relationship between color and flavor perception, delving into the world where sensory cues interact with cognitive processes. Contrary to popular belief, taste perception extends beyond the mere taste buds, encompassing a complex web of sensory inputs including visual and olfactory cues. The hypothesis suggests that variations in the color of a tasteless liquid may result in corresponding shifts in perceived flavor. Through careful experimentation, the aim is to investigate the connection between visual observations and flavor perception. Findings reveal compelling evidence supporting the hypothesis, shedding light on the intricate relationship between color and flavor perception. Statistical analysis uncovers significant variations in participants' flavor perceptions across different

color conditions, pointing toward the profound influence of visual cues on taste experiences. Beyond the confines of sensory exploration, the implications of the research extend to broader applications, including advancements in technology and healthcare. In conclusion, the study marks a significant step in unraveling the mysteries of human perception, shedding light on the complex interplay between sensory inputs and cognitive processing. By pronouncing the relationship between color and flavor perception, the experiment contributes to the growing body of knowledge in neuroscience and paves the way for harnessing the potential of sensory experiences for the betterment of society.

Maya Aravindan -The Effect of a Group of Musical Notes on the Various Emotions Felt by Listeners
George H. Moody Middle School

Emotions are a pivotal part of everyday life. They help us regulate the mind and body and are usually triggered by memories, people, places, objects, etc. Triggers are connected to thoughts, experiences, and memories, and music is one of the factors that trigger emotions. Studies have shown that even when a patient who suffers from brain injuries cannot distinguish a specific melody, they still remember what emotion they felt towards a specific piece of music. Another study showed that about 50% of people get the “chills” when listening to music. The purpose of this project was to determine what emotion was invoked in the listener when playing a group of musical notes. If minor keys are used while playing the instrument, then it can evoke a sad/nostalgic feeling. Two recordings were played to the listener. The first consists of minor keys and the second consists of major keys. 40-50 surveys were made for listeners to rate their level of emotion. Each survey had 6 choices, Happy, Relaxed, No difference, Mysterious, Nostalgic, and Other. This process was repeated another 49 times, and the results were recorded on a table and graph. During the experiment, the instrument used, notes played, surveys, and recordings were kept the same. The results showed that the majority of the listeners felt mysterious towards the first recording (minor keys) and felt relaxed towards the second recording (major keys). 11.36% felt nostalgic after listening to the first recording, and 18.18% felt nostalgic after listening to the second recording. The data supported the research hypothesis as listeners felt nostalgic after listening to the first recording.

Hridhay Pothunoori, Ritvik Adusumil – The Effect of Screen Time on Efficiency of Completed Tasks

George H. Moody Middle School

Our contemporary society has grown excessively reliant on technology via the utilization of phones, computers, and television, to the extent that life would be arduous without these devices. Understanding the ramifications of technology could undoubtedly prompt one to make alterations in regard to how they live and the influence they are subjected to by screens themselves. The experiment of discovering the effects of screen time on the efficiency of completed tasks resonates with millions of flourishing careers in almost every possible field by providing data on how one could do work more efficiently. Concurrently, to complete this experiment, one researcher would begin by handing over 15 questions each on an individual paper and would measure the time taken by the subject for each question. At the culmination of the test, the researcher would subsequently document the accuracy and time taken for each question and compare it to create accurate results among the subjects. Using the data amassed, we concluded that those with an increased screen time (>2:30) took a greater amount of time when completing each of the fifteen questions when compared to the individuals with a decreased screen time (<2:30). Ultimately, the experiment provided ample data which was not only conclusive but flawless when compared to other experiments which had many outliers. Our hypothesis, "If the student's screen time is increased, then they will complete tasks less efficiently," was proven to be accurate, as high screen time subjects took a greater time to complete the test. With empirical results and data, the test is both reliable and trustworthy. The outcomes of other experiments closely mirror our findings, with the primary distinction being that our data is derived from students aged 12-15 years, resulting in more precise results, whereas other experiments encompass a significantly broader age range.

PA – Physical Science and Astronomy

Second Place

Ananya Sankepalli -The Effect of Different Types of Light on the Fading of Fabrics

George H. Moody Middle School

Fabric was a versatile material that can be made from a variety of natural and synthetic fibers and is often chosen for its durability. Clothing provides a barrier between the skin and the external environment and serves a variety of

functions, which include protection from harmful UV rays, social and cultural purposes, and thermoregulation, (*et al*, 2021). An experiment was conducted to investigate the impact of different types of light on a fabric's long-lasting abilities. By understanding how different types of light affect fabric durability, professionals can develop products that are more resistant to fading and better suited for a variety of uses. The research explored the effects of UV light, light-emitting diodes (LED), fluorescent light, and darkness on the colorfastness of fabrics. The hypothesis was that natural light would cause the most significant fading. The fabric was cut into squares and placed under a specific type of light. The fabric was checked every day to determine any changes that occurred. The results of the study demonstrated that the fabric exposed to UV light received the lowest rating (IV) for lightfastness, indicating a large impact on the fabric's durability. In contrast, the fabric exposed to no light received the highest rating for lightfastness (I), indicating excellent durability. The fluorescent and LED lights produced similar results, with both receiving fair (III) to good (II) ratings for lightfastness. The hypothesis was supported by the data collected by the experiment. The reason for the fabric's fading is due to photodegradation which caused the chemical composition of the fabrics has broken down. Overall, the experiment provided valuable insights into the most effective ways to preserve the color of fabrics which will be important information for numerous professions.

Third Place

Beckett Shepherd -The Effect of Apple Wrapping on Oxidation Time

Swanson Middle School

When I was in elementary school, my mom or dad would make my lunches for me. Whenever he made lunch, he was sure to pack some apple slices, so I got the nutrients I needed. However, when I opened my lunch, I would find brown apples. I never liked the oxidized apples and would often throw them out because of that. To this day I still am not a fan of browned apples, which is why I decided to test the effect of apple's wrapping on oxidation time. I wanted to know which wrapping kept them fine for the longest time, so I didn't have to deal with more disgust than I already have for apples. For the wrappings I chose Saran Wrap and plastic bags because those are the most commonly used wrapping in my household and have been for a while. In my hypothesis, I stated that the apples would be kept from oxidizing the longest when stored in Saran Wrap because of the way that it clings to the apples, and I thought that would keep the oxygen from reacting to the flesh of the apple, and my hypothesis was technically not supported by my data, with the plastic bag group taking more time to oxidize than the Saran Wrap (336 seconds compared to

335 seconds). However, I think that my experiment was inconclusive due to the closeness of the averages and the variety in the ranges (491 seconds for the plastic bag compared to the 337 seconds).

Maedot Ayalew -The Effects of Seasonal Variation on the Kinematics of Coronal Mass Ejections Using the Solar and Heliospheric Observatory Satellite
Individual

Every day, multiple enormous bursts of plasma come from the outermost layer of the Sun, the corona. This violent phenomenon is called a coronal mass ejection (CME). CMEs are extremely destructive, yet they are full of mystery. The more scientists find about the properties and behavior of CMEs, the better people can protect satellites and provide safety during space exploration. This project looks at which season the kinematics of CMEs are the greatest. The SOHO LASCO CME catalog is a database that has coronagraphs (videos of CMEs). The positions of features in 60 coronagraphs were measured. The data was then used to calculate the velocity and acceleration of the CMEs for each month from 2018-2022. The hypothesis is that during fall and spring, the kinematics of the CMEs will be the greatest. The results supported the hypothesis by showing that the velocity(m/s) was greatest in the fall, followed by spring, and the acceleration(km/s²) obtained the opposite results. As stated above, CMEs are extremely harmful to various things, one of which is satellites. People use satellites for services like communication, GPS, weather forecasting, and financial transactions. CMEs and geomagnetic storms, which are caused by CMEs, can damage satellites. Additionally, an obstacle for space exploration is the harmful effects solar events would have on humans on missions that go beyond Earth's magnetic field. By knowing what seasons the greatest kinematics on coronal mass ejections have, scientists can avoid those time periods.

Amisha Chopra -The Effect of Different Materials Covering the Stem of the *Musa paradisiaca* on Its Enzymatic Browning
George H. Moody School

Fruits and vegetables are a crucial part of the diet of millions of Americans, and a popular fruit is the *Musa Paradisiaca*. When the stem of a *Musa paradisiaca* is covered with any type of material, it slows down the release of ethylene. Ethylene is an important plant hormone. To experiment with the ripening process of the *Musa paradisiaca*, gather five individual *Musa paradisiacas* and

place them 0.4572 meters apart on a table. Proceed to wrap the stem of each *Musa paradisiaca* with different materials. Of the ten days the banana stems were wrapped in different materials, the *Musa paradisiacas* covered in cloth and cling wrap had the least amount of enzymatic browning at the end of the testing period, and the bananas with no covering had the most. The primary objective of this experiment was to investigate the impact of different materials used to cover the stem of *Musa Paradisiaca* on enzymatic browning, particularly when compared to other uncovered bananas. Upon analyzing the results, it became evident that bananas with stems enveloped in cloth exhibited the least enzymatic browning at the conclusion of the testing period. This outcome provided substantial support for the initial research hypothesis postulated by the experimenter. Remarkably, the results closely mirrored those obtained in parallel experiments exploring the same topic, suggesting a consistent pattern in the data across different studies. Furthermore, increasing the number of trials would bolster the statistical significance of the results, ensuring a more comprehensive understanding of the variables at play.

Preston Wong -The Effect of Fibers on Blocking UV rays
George H. Middle School

Ultraviolet rays or “UV” Rays can be very dangerous to be exposed to. Tens of thousands of people die from UV ray exposure a year. Some ways of blocking these harmful rays are creams and different kinds of fibers. My hypothesis was that if the fiber was thicker, it would block more UV rays. In my experiment, I tested which fibers were the most effective at blocking UV rays. To do the procedure, you have to put a UV light source over a fiber with the detector under it. After the experiment, my hypothesis was mostly supported but researchers also came to similar conclusions.

PM - Plant Sciences and Microbiology – A

First Place

Eshaan Patel The Effect of Light Source Color Temperature on CO₂ Absorption by Houseplants.

George H. Moody Middle School

Several studies have shown the correlation between wavelength of light and CO₂ absorption, but they aren't practical because lights in most places, including households use light in the color temperature spectrum (measured in Kelvin or

K). Climate change caused primarily by Carbon Dioxide (CO₂) is currently a huge issue and is affecting the world in all sorts of negative ways. Plants can help get rid of CO₂, so the implications of the student's findings include fighting the climate crisis, along with helping people like plant growth manufacturers develop better products and finding the best places to go in the future when settling in outer space. The experimenter's hypothesis was: If different color temperatures of light were used to determine CO₂ absorption by houseplants, then the redder wavelengths would result in maximum CO₂ absorption. The experimenter set up the experiment by placing snake plants and bamboo plants, which had been previously acclimatized to the house where the experiment was being conducted, into airtight tents with a CO₂ meter inside. The CO₂ in the tents with different color temperatures of light (3000, 4000, 5000, and 6500K) was measured after zero, 30, and 60 minutes, with statistical analysis being run on the data afterwards. The results didn't support the hypothesis and showed that only 4000K had a significant p-value for the results, and it was by far the most effective, while 3000K and 6500K lights were largely ineffective. This is because of the combination of red and blue light in the 4000K that was shown by one study to be most effective, while the rest were as effective as they were because of the combinations of red and blue light in them.

Second Place

Siddhant Naavaal -The Effect of Sugar Content in Soil on Root Growth and Germination Rate in White Clover (*Trifolium repens*).

George H. Moody Middle School

In the past few decades, soil has endured many farming practices that humans attain annually. This causes erosion, runoff, and a loss of nutrients in the soil. Soil degradation is similar to these, describing a decline in soil health such as the mineral content. Soil degradation can tie to global warming and food crises due to less nutrients in the soil, while indirectly affecting humans. The researcher conducted a study to measure the root growth and germination rate of *Trifolium repens* (white clover) with relation to sugar in soil. The I.Vs were Control, 1g, 2g, and 3g of Sugar. The procedure had 10 cups of the same size, soil quantity, amount of sugar, and was watered daily for 21 days with each IV's process being repeated. The hypothesis stated, "If the sugar content increases in soil, then the root growth of *Trifolium repens* or white clover will increase, and additionally, the germination rate time would decrease". The averages of the root growth were Control - 5.25 cm, 1g - 5.55 cm, 2g - 6.0 cm, and 3g - 5.64 cm. Data "means" for germination rate included Control - 2.70 days, 1g - 2.60 days, 2g - 3.20 days, and 3g - 3.40 days. These findings conclude that

root growth excels in white clover with the presence of sugar in the soil. However, the findings didn't support the germination rate hypothesis. Sugar as a potential fertilizer and soil degradation prevention could perhaps work for the future of humans.

Third Place

Rajat Mallick - The Effect of Soil Type on the Germination and Height of Chili Plants(*Capsicum annuum*)

George H. Moody Middle School

Chili plants are one of the most important plants in human society. They are used in homeopathy and certain medicines. They are also used for their spiciness. Because of the importance of chili plants, making the growth of the plants faster would benefit society and increase yield for each crop. In order to assist this cause, the experimenter wanted to test how different types of soils would affect the heights of chili plants. The experimenter's levels of IV were compost soil, sandy soil, peat moss, and gardening soil. Each level of IV had ten plants for each, and the plants were left to grow for 2 months, with an adequate amount of water and sunlight. The experimenter hypothesized that compost soil would have the tallest plants. After the experiment concluded, the plants had average heights of 3.95, 3.8, 0, and 3.56, for garden soil, sandy soil, compost soil, and peat moss, respectively. In conclusion, it was found that garden soil made the plants grow the tallest.

Honorable Mention

Rithik Natarajan -The Effect of Limited Space on Plant Nutrition and Growth

George H. Moody Middle School

The researcher performed an experiment to find out the effect of the amount of space each plant had to grow on how tall the plants grew. The four levels of independent variables included twelve trials for each level with the plant planted progressively closer to each other. The data from the experiment supported the researcher's hypothesis and showed that there is very little correlation between the amount of space each plant has to grow and the amount that plant can grow.

Honorable Mention

Sophie Guo - The Effect Different Drinks Have on the Growth of *Escherichia coli*

George H. Moody Middle School

Escherichia coli (E.coli) infects about 48 million people in the US every year through many different means. The different drinks were inoculated with E.coli and grew for 16 hours. The results showed that milk had supported the growth of E.coli the most, and most other drinks did not grow any, but orange juice did support the growth of the bacteria a little. This happened for many reasons, such as acidity, needed nutrients, alcohol content and sugar or carbonation. This experiment would be helpful to know what drinks you shouldn't leave out overnight.

Saamiya Mehta - The Effect of Various Plants on Their Growth Using Hydroponics

George H. Moody Middle School

Hydroponics has been said to be the new agricultural way of farming. Since around 1860, hydroponics has been developing into a method of agriculture that doesn't need soil to produce crops (Lagomarsino, 2019). This way of agriculture has been spreading throughout the last few decades and has been adopted by many individuals and countries in our world. Hydroponics has been an efficient, agricultural way to save water as well as grow crops quickly which can assist countries with severe weather conditions. The purpose of this experiment was to grow various vegetables in a quicker and reliable manner that could allow the plants to grow healthy and taller. Hydroponics could be used for countries that aren't able to receive as much water and soil as other countries do. The hypothesis of this experiment was that if tomatoes were applied, then they would grow the tallest according to hydroponics. This hypothesis was not supported by the experiment because of the lack of full evaluation of each vegetable. The procedure of this experiment consisted in the making of the containers as the plants were grown in two-liter bottles. These bottles were cut open and assembled so the mouth of the bottle laid on top of the body of the bottle which was then filled with coconut coir. Nutrient-rich water is created and watered to the plants about three times a week. The results of this experiment were that cucumber grew the tallest and healthiest throughout the three weeks of the collection of data. The cucumber plants had an average growth of 15.95 centimeters which concluded that cucumber plants were the most efficient, healthiest, and tallest plant to grow using hydroponics. The

growth rate of cucumber plants was about 5 centimeters each week. In conclusion, the plants grew taller and healthier with the nutrients that were included in the nutrient-rich water. Overall, the healthiest and tallest plants were cucumbers.

PM - Plant Sciences and Microbiology - B

First Place

Aditya Singhal - Effect of different application methods of citric acid on the growth of *Oryza sativa* (rice)

George H. Moody Middle School

Several studies have shown the correlation between wavelength of light and CO₂ absorption, but they aren't practical because lights in most places, including households use light in the color temperature spectrum (measured in Kelvin or K). Climate change caused primarily by Carbon Dioxide (CO₂) is currently a huge issue and is affecting the world in all sorts of negative ways. Plants can help get rid of CO₂, so the implications of the student's findings include fighting the climate crisis, along with helping people like plant growth manufacturers develop better products and finding the best places to go in the future when settling in outer space. The experimenter's hypothesis was: If different color temperatures of light were used to determine CO₂ absorption by houseplants, then the redder wavelengths would result in maximum CO₂ absorption. The experimenter set up the experiment by placing snake plants and bamboo plants, which had been previously acclimatized to the house where the experiment was being conducted, into airtight tents with a CO₂ meter inside. The CO₂ in the tents with different color temperatures of light (3000, 4000, 5000, and 6500K) was measured after zero, 30, and 60 minutes, with statistical analysis being run on the data afterwards. The results didn't support the hypothesis and showed that only 4000K had a significant p-value for the results, and it was by far the most effective, while 3000K and 6500K lights were largely ineffective. This is because of the combination of red and blue light in the 4000K that was shown by one study to be most effective, while the rest were as effective as they were because of the combinations of red and blue light in them.

Second Place

Lucian Pozzi -The Effect of Black-strap Molasses as a Foliar Fertilizer on the Propagation and Leaf Growth of the Critically Endangered Species *Stachys matthewsii*

Sabot at Stony Point

This experiment was designed to determine the best growing method for the native and endangered plant *Stachys matthewsii*. During this experiment, a hydroponics growing system was set up to grow the plant. The experiment was a continuation to a previous experiment where a relative of *Stachys matthewsii* called Lamb's Ear was propagated in three different growing systems as a surrogate in order to ensure the safety of this plant since there are so few of these plants left. In order to conduct this experiment, the *Stachys Mathewisii* was collected from a field in East Henrico in the summer (See figure 5 for exact location) then made into cuttings and brought to the University of Richmond Greenhouse for propagation. This project is critical to the health of the entire species because this plant only exists in the field, we found it in and one place in southern Virginia. A second set of cuttings was then made, and those plants were transferred to the Hydroponic Growing Tower. The *Stachys matthewsii* cuttings are similar in shape and size. The *Stachys matthewsii* were then transplanted to a hydroponics growing system. One-third of the group was put in the 45mL blackstrap-molasses sample group. One-third was put in with the 75mL blackstrap molasses group. The last third of the plants were put in the no spray group. The plants were analyzed based on the number of leaves they grew. It was hypothesized that the *Stachys matthewsii* that was sprayed with forty-five milliliters of blackstrap molasses twice a day would grow more than the plants sprayed with seventy-five milliliters of blackstrap molasses and the ones not sprayed at all because the molasses was the required amount for the plants cells to give the plant the energy and help promote microorganisms. The hypothesis was supported by the data that was collected because the sulfur in the black strap molasses at 45 ml provided optimal growth. Both higher and lower levels of sulfur resulted in lower leaf count.

Third Place

Vikram Puranik - Effect of Salinity on Seed Germination in *B. oleracea*

George H. Moody Middle School

Seed germination is one of the most crucial stages of plant growth, but it is also one of the most vulnerable (Debouza et al, 2021). In today's world, urbanization and climate change are increasingly affecting such processes, with pollutants,

such as heavy metals, hydrocarbons, and salt, entering the environment in increasingly high concentrations (Das et al, 2023). This experiment investigates the effect of salinity, a very abundant compound that is shown to inhibit some cell processes, on germination, to better understand the implications that salinity, which has increased in the past decades due to climate change and industrial activities, can have on crops and the agricultural industry as a whole. Due to said evidence demonstrating salinity's harmful effects on plants, the hypothesis in this experiment was that higher salinity, in this case, higher concentrations of sodium chloride, would result in lower rates of germination. This experiment was carried out in late January using Petri dishes as the place of germination, with 10 trials for each independent variable and 15 seeds in each trial. The results confirmed the hypothesis, showing an inverse relationship between the concentration of salt and the rate of seed germination. This was backed up by the results, which showed a 32.01 percent decrease in seed germination percentage between the control, without any salinity, and the fourth independent variable of 60 grams of salinity. Besides this, the experiment also showed that out of the trials with higher salinity, even seeds that did germinate were significantly slower to do so than the seeds in the control. This experiment affirmed the results of other similar papers, though the degree to which salinity had a major effect was different in other experiments.

Tanvi Patil - The Effect of Salt Water on the Growth of Plants
George H. Moody Middle School

Many places in the world don't have access to fresh water, preventing them from watering their crops. The experimenter chose this experiment because it will not only help people all around the world, but she has a deep passion for understanding plant behavior. This experiment will investigate if we add no or little salt then the plants will grow better as compared to more salt. For this experiment, the researcher took 48 different pots; 12 pots for each level of IV. She filled them with loamy soil and planted one seed of fenugreek in each pot. The first 12 plants were watered with 0% salt, the second level of IV had approximately 0.1% of salt in their water, the third level of IV was watered with 0.2% of salt, and the last level of IV was watered with 0.4% of salt in the water. The experiment was performed for 2 weeks, and the results stated that the last two levels of IV did not survive. The first level of IV, the one with 0% salt, had all of its plants thriving. The second level of IV had 10/12 plants that survived, so the experimenter concluded that plants can survive with 0.1% of salt in them, but no more than 2% salt.

Adityasinh Raol - The effect on the number of flies fed to a Venus flytrap in week on its mass.

George H. Moody Middle School

The interaction between Venus's flytraps and their prey, particularly flies, is an example of nature's ingenuity. Horticulture researchers have been investigating ways to properly feed carnivorous plants of all kinds for centuries. In the experiment that was conducted, results have been found on how much one can feed a flytrap per week without causing it any harm or negative effects. One of the many purposes of this experiment was to analyze this interaction and record the data shown. Before conducting the experiment, the hypothesis that was chosen was that if a Venus flytrap 2 times a month it will have gained the most mass. Conducting the procedure for my experiment was very simple with the costliest instrument, being only a \$30 weight scale, accurate the 0.001th of a gram found on the popular shopping website amazon. Each pot weighed 75 grams and the mean of the soil was was 320.55 grams. No results were taken during the first 3 weeks because of the danger that the germination can interfere with the results of actually feeding the plants. The results of this experiment showed that overfeeding your plants does not have many negative effects but is a general waste of resource and money as said before. Venus's flytraps can be fed up to 4 times a week before it starts secreting the food back. Overall, the experiment was successful, and I would recommend others to try it out for themselves too.

Shrevash Setty -The Effect of Different Weather Conditions on Marigold Flowers

George H. Moody Middle School

Flowers depend on weather conditions since they need the proper amount of rain and sunlight to survive. We need these plants because 72.9% of people include flowers in their gardens. A type of these flowers that greatly help with keeping gardens healthy is the marigold. Marigold flowers not only attract pollinators like regular flowers, but also predatory insects such as ladybugs and hoverflies that will get rid of creatures harmful to your plants such as aphids. The independent variable in this experiment was the weather conditions that were affecting the dependent variable, the marigold flowers. There is no control group in this experiment because it is a very difficult process to find so many flowers that measure the exact same height. Since the difference between the original height of the marigold and the height after twelve hours are the things

being measured, there is no reason to have a control. There will be no difference between having all the plants the same height or different heights. The hypothesis is if a marigold flower is left outside in hot weather, then it will survive better than if in rainy weather. The results of this experiment will be beneficial to anyone trying to grow marigold flowers in their backyard. This can also help anyone working in the field of botany since they will be able to grow their marigolds much faster and healthier.

PM - Plant Sciences and Microbiology - C

First Place

Aasiyah Vohra -The Effect of Salicylic Acid ($\text{HOC}_6\text{H}_4\text{COOH}$) on the Growth Rate of *Penicillium italicum*

George H. Moody Middle School

This experiment tested the effect of salicylic acid on the growth rate of *Penicillium italicum*. The independent variable was the concentration of the salicylic acid, a compound widely used in skincare. *Penicillium italicum*, also known as blue mold, commonly infects citrus and its growth was the dependent variable. The growth was measured on a qualitative scale from one to five, where one represented little change and five represented the most. The purpose was to determine ways to prevent post-harvest pathogen growth in mass-produced products. Vendors of these fruits, such as Brazil, report loss of product due to these pathogens. If solutions are found, loss can be limited. There were four levels of the independent variable, each with 10 trials: a control, which was the 0% solution, a 15%, 30%, and 50% solution. The hypothesis stated that if a 30% solution was applied on *Penicillium italicum*, then it would be most effective in breaking down growth. The experimenter grew the mold in petri dishes, applied the solution, and after 24 hours, measured the growth. The experimenter wore eyewear, gloves, a mask and an apron for protection. The least effective level was the control, which showed minimal change and the most, the 50% solution. The average for the control was 1, 1.95 for the 15% solution, 2.4 for the 30%, and 3.075 for the 50%. As the concentration increased, the limitation of mold growth grew. For further study, we can investigate if effective solutions are safe for human consumption.

Second Place

Aarna Vachhani -The Effect of Different Species of Plants on Carbon Dioxide (CO₂) Levels

George H. Moody Middle School

Global warming has had a tremendous impact on our planet. To help address this issue, the researcher conducted an experiment to evaluate which plant species would decrease the carbon dioxide (CO₂) levels the most, out of Pothos, Ferocactus, Aloe vera, and Neem. The hypothesis stated that if these four species are kept in a certain area, then the Pothos plant would be most effective in decreasing the CO₂ levels due to its foliage. The experimenter bought ten of each plant and measured the CO₂ in the container with a CO₂ meter in particles per million (ppm). The plants were sealed in a container for two days, and then CO₂ levels were again measured, followed by a day of keeping them open to prevent wilting. This process was repeated over 21 days. Pothos had the highest closed container readings with an average of 3,161.6 ppm. Its open container reading averaged at 863.6 ppm. Ferocacti had the lowest carbon dioxide readings for closed containers with an average of 1,185.3 ppm. Its open container readings averaged at 869.9 ppm. Aloe vera and Neem measurements were in between those of Pothos and Ferocactus. The overall CO₂ level in the ambient air decreased at the end of the experiment with an average of 874 ppm compared to the baseline average of 1,343.8 ppm. The initial hypothesis was inconclusive because the CO₂ measurement was affected by CO₂ production from the soil biome and decaying leaves. With this limitation in the experiment, Ferocactus appeared to be the best at stabilizing CO₂ emissions based on the least mean difference in the CO₂ measurement between closed and open containers. However, it would be difficult to conclude which plant truly contributed the most to the overall decrease in CO₂ level in the surrounding air. The experiment could be improvised by measuring carbon dioxide values separately for each species at different times for a better comparison.

Aarnav Rudraraju - The Effect of Different Mediums on the Growth of *Pilea pepermoides* Roots

George H. Moody Middle School

We need soil to survive simply because most of our food comes from plants. Plants grow from soil due to the fact that it provides them with nutrients. This means that we don't need soil to grow plants in. This experiment is to find out what medium plants grow best in. There are many benefits to society if plants

grow faster. A major problem in the world currently is world hunger. As we all know plants provide us with oxygen and food. According to UN News, plants provide us with 80 percent of the food we eat (UN News, 2019). According to Feeding America, so far this year about 34 million people are food insecure in the USA itself (Feeding America, 2022). If we have a faster way to grow plants organically without the use of chemicals, we can stop a portion of hunger in the world. If I use water, then I will get more height grown in a plant in less time. The following materials were gathered: forty-six-ounce cups were used to plant forty *Pilea peperomioides* pups, one pound of gravel, soil, sand, and a gallon of water were used as the different mediums and a pound of 20-20-20 water-based fertilizer was used for the ten water cups. Each of the different cups was filled with different mediums of the same amount placed in the same spot and watered with the same amount of water. The average growth of the plants in the soil was three millimeters bringing the total growth to ten millimeters. The average growth of the plants in the water was one millimeter, bringing the total growth to five millimeters. The average growth of the plants in the sand was zero millimeters, bringing the total growth to two millimeters. The plants that were in gravel averaged about one millimeter of growth. In conclusion, farmers or families that want to grow plants now can use water as another effective way to grow plants if soil is not available.

Aanya Vadlamudi - The Effect of Homemade Organic Compost and/or Fertilizer on Plant Growth

George H. Moody Middle School

The problem the experiment addressed was the effect of homemade organic fertilizer on plant growth. The experimenter gathered four lettuce plants and placed them inside the house in different areas. Each plant was given the same amount of water, sunlight and soil, although they were given different types of nutrition. Nutrition is very important for plant growth. The experimenter hypothesized that the plant with both compost and fertilizer would have the best growth. However, it was unclear if adding fertilizer, organic compost, neither, or both to the soil would help plant growth. In this experiment, the experimenter measured the type of nutrition for plants that helped the plant grow. Plant One was given only compost, Plant Two was given only fertilizer, Plant Three was given neither compost nor fertilizer, and Plant Four was given both compost and fertilizer. The experimenter would test this for eight weeks and record the data after each week. After eight weeks, the experimenter concluded that Plant Four had the greatest growth, growing up to four inches. The main purpose of this experiment was to investigate the growth of a lettuce plant. Since all the

other plants had somewhat extra nutrients, they were able to grow taller than Plant Three. According to research, compost is most well-known for its contribution to healthy and resilient plant growth. It balances soil density, adds and retains nutrients, and discourages diseases, pests, and weeds. On the other hand, fertilizer improves the supply of nutrients in the soil, directly affecting plant growth. Some people prefer to use fertilizer to supply plants with specific nutrients that are lacking in the soil. However, the best solution is to use both. Compost works well with fertilizer, sponging up and storing the nutrients until they are needed by the garden plants.

Kevin Wen -The Effect of Soluble Mineral Compounds on Arugula Growth
George H. Moody Middle School

Arugula, a leafy green that supplied various crucial nutrients to the human body, was enduring a drastic shortage in production due to severe weather conditions. As a result, millions of individuals were not receiving ample sustenance and developed side effects that substantially impacted daily life. To offer a resolution to the problem, the experimenter attempted to discover a reliable growth-accelerating soluble mineral compound, which included zinc sulfate, potassium nitrate, magnesium sulfate, calcium nitrate, and water as the control, to apply on arugula plants as a dissolved liquid to fertilize the greens. The hypothesis for the experiment was, "If the arugula plants received zinc sulfate, then they would grow more." During the growth stage, mineral compounds combined with water, along with the control, plain water, were each sprayed on 16 separate arugula plants twice a week for 30 days. In the end, the recorded averages for each level of the independent variable were as follows: water 5.50 cm, zinc sulfate 5.69 cm, potassium nitrate 5.84 cm, magnesium sulfate 5.64 cm, and calcium nitrate 5.83 cm. Moreover, the arugula plants impacted by water had a standard deviation of 0.28 cm, zinc sulfate 0.33 cm, potassium nitrate 0.46 cm, magnesium sulfate 0.31 cm, and calcium nitrate 0.25 cm. Evaluating the results, the experimenter discovered the hypothesis was not supported, and the potassium nitrate solution was the most effective at boosting arugula development rather than zinc sulfate.

Nisarg Ujaria - The Effect of Music on the Growth of Sunflowers
George H. Moody Middle School

Sunflowers help us in a lot of ways. Sunflowers can make sunflower oil or seeds which are healthy and organic foods. Sunflower oil is also a great

alternative to people who are allergic to peanut oil. The experimenter did this project in order to grow sunflowers faster. Succeeding in this project could potentially end the global food crisis. The hypothesis is if the plant listens to classical music, then it will grow the most. First, the experimenter took forty cups and planted sunflower seeds in them. Every three days the experimenter watered the plants and every other day the experimenter played music to each of the plants. The hypothesis was supported because classical music had the highest average of growth. This happened because the sunflowers react best to soothing vibration.

High School Sections

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Botany - A

First Place

Tyler Radtke -The Effect of the Percentage of Surface Area Coverage of Water Lilies in Walton's Lake on pH, Dissolved Oxygen, and Turbidity Per Plot
Clover Hill High School

The purpose of the experiment was to determine the effect of the presence of water lilies on the dissolved oxygen, pH, and turbidity in the water. A common debate has been held in communities to determine the effects of unnaturally removing water lilies and this research allows people to review the true effects of the presence of water lilies. To measure the effect the water lilies had on the pH, dissolved oxygen, and turbidity of the water, a system was devised to separate portions of Walton's Lake into areas with varying densities of water lily surface area coverage ranging from 0% to 100% surface area coverage. Over the course of five days, each plot was measured for the aforementioned aspects of water and the measurements of the aspects of the water were recorded. The hypothesis was that for more water lily surface area coverage per plot, there would be less dissolved oxygen, more turbidity, and a lower pH per plot. The general results concluded that the pH and turbidity showed no substantial change from the change of surface area coverage of the water lilies. However, the dissolved oxygen showed a slight decrease. The null hypothesis was not rejected for the pH and turbidity. The null hypothesis was rejected for the dissolved oxygen. The dissolved oxygen did show some trend.

Second Place

Saanvi Sooda -A Comparison of Solute Concentration of Aqueous Fertilizer on Stem Elongation of Hydroponic Fenugreek
Mills E. Godwin High School

The purpose for conducting this experiment was to measure and analyze the effects of the concentration of solute in water-soluble aqueous fertilizer on the stem elongation of a hydroponic fenugreek seedling grown hydroponically. With the human population rapidly heightening rather than stabilizing, it is vital that society is supplied with necessary quantities of food and mandatory nutrients. Scientists and horticulturalists are constantly experimenting and searching for

the most efficient methods for farming these nutrients. The fenugreek plant is utilized internationally in many industries, including pharmaceuticals, specifically to alter hormone levels and promote lactation. Prior to experimentation, a research hypothesis was formulated estimating that if the plant received a solution consisting of one and half tablespoons of fertilizer along with 250 mL of distilled water in a solution, then the seedling would display the most beneficial stem elongation. Three garden propagation trays concealed by a humidity dome resided in an insulated grow tent. In each tray, the hollows of 25 seedling starter plugs specifically utilized for hydroponics were each filled with a fenugreek seed. Each tray received a different concentration of solute (plant food) in the aqueous fertilizer; the concentrations consisted of: zero tablespoons of plant food, one and a half tablespoons (recommended by the manufacturer, therefore the control), and three tablespoons. All trays were placed on heating mats used specifically for botanical purposes in order to maintain condensation and evaporation, replenishing the tray's water supply. Three weeks later, the seedlings were removed from the trays and the stem's elongations were measured using a ruler (in centimeters). The collected data supported the hypothesis, as the average heights of the seedlings consisted of the following: zero tablespoons (4.9 cm); one and a half tablespoons (9.9 cm); and three tablespoons (8.4 cm). Three t-tests were conducted, displaying that all data collected was statistically significant. These calculations depict the results likely being due to the independent variable rather than chance. This showcases that the control group creates the most substantial growth, and the level zero tablespoons displays the least advantageous growth.

Third Place

Scott Pabis -The Effects of Growth Restrictions on *Raphanus sativus*
Central Virginia Governor's School for Science and Technology

The purpose of this research is to observe if the mass of a radish (*Raphanus sativus*) changes based on the volume of soil it is grown in. Three groups of radishes, grown in differing volume planter pots were tested (449mL, 148.6mL, and 8.15mL). By using the same soil and lighting setup all of the radishes were in the same soil conditions for the duration of the testing. After thirty days had passed, the radishes were harvested, cleaned, trimmed, and then weighed. This allowed for accurate and consistent data throughout the three trials. The results showed that there was a significant difference between the 449mL group and the 8.15mL group, as well as the 148.6mL group and the 8.15mL group. To determine this, a one-way ANOVA was used and calculated the p-value to be 1.99×10^{-5} with an alpha value of .05, which indicated that there was a

significant difference within the data. As a result the means (2.416g, 0.715g, 0g) were run through a post hoc Tukey test to determine where the significance was within the data. The hypothesis, “when restricting the growth of a *Raphanus sativus* (radish), then its average yield will decrease when it has less than 75% of its recommended space to grow”, was supported by the data. The study found that as you decrease the volume of soil, the mass of the plant decreases, meaning this would not be an effective way to increase crop production.

Honorable Mention

Siddarth Siddabattula -The Effect of Mycorrhiza on *Trigonella foenum-graecum* in Acidified Soil

Mills E. Godwin High School

The application of arbuscular mycorrhiza on fenugreek plants in acidified soil was investigated in this experiment. Arbuscular mycorrhiza is a fungus that forms symbiotic relationships with the roots of plants, and the purpose of this experiment was to investigate the effects of soil acidity on this symbiotic relationship and possibly use the results to help farmers further optimize their mycorrhiza usage. Mycorrhiza concentrations of either 0% total soil mass as a control, 5% total soil mass, or 10% total soil mass were added in soil that contained fenugreek seeds and the seeds were left to grow for 4 weeks. It was hypothesized that the mycorrhiza concentration of 10% would yield the most growth in the fenugreek plants. The hypothesis was supported by the data and the increase in growth from the control group to the 5% and 10% mycorrhiza groups was significant, though the increase from 5% to 10% was not. This indicates that rather the relationship between mycorrhiza concentration and fenugreek growth in acidic conditions isn't direct but is instead logistic. There is an initial increase in crop yield as mycorrhiza is added in acidic conditions, but the increase in yield decreases as more mycorrhiza is added past a certain threshold. The results of this study can likely be applied to other legumes and the data can help farmers and plant growers optimize their arbuscular mycorrhiza usage and potentially reduce environmentally unsafe fertilizers.

Honorable Mention

Catherine Thornton - How Different Colors of LED Lighting Affect Growth in Wheat Crops

Central Virginia Governor's School for Science and Technology

The purpose of this research was to determine if there was a significant

difference between the heights of wheat crops grown under different colors of LED lighting. Two-inch planter pots housed each group of sixteen wheat crops (control, red, blue, purple). They were grown for five weeks and received water until they were saturated at least twice a week, and plant heights were recorded each week in centimeters. The resulting averages on week five for each group included 28.838 centimeters for control, 26.925 centimeters for red, 27.319 centimeters for blue, and 27.294 centimeters for purple. To analyze the data, a single-factor ANOVA statistical analysis test was run, however, the results indicated that there was not a significant difference between the groups. The alpha-value of .05 was used and the resulting p-value was .502. The research hypothesis stated that if wheat plants are exposed to blue lighting as compared to red, purple, and normal white lighting, then they will germinate and grow faster. Therefore, the research did not support the research hypothesis and there were no statistically significant differences between the groups. This study focused on implementing agricultural advancements to optimize crop growth.

Patel Dharya -The Effect of Natural Fertilizers on Beanstalk Plant Height
Mills E. Godwin High School

The purpose of this experiment was to find the effect of natural fertilizer on beanstalk plant height. Many countries around the world have been using inorganic fertilizers which has been harmfully affecting the soil and environmental health. The beanstalk plant was fertilized with 30 mL of eggshells, bone meal, kelp powder, or oyster shells for 4 weeks being measured at the end of every week. The control being used was water. It was hypothesized that bone meal will have the greatest effect on beanstalk plant heights compared to the rest of the fertilizers. The results implied that plants with eggshells had a faster growth rate and grew higher than the comparable independent variables. A t-test was performed on the data which revealed that the data was not significant, and the null hypothesis was not rejected. This could be due to the fertilizers containing similar types, and quantities of minerals. This investigation can be extended by comparing inorganic fertilizers to organic fertilizers with similar mineral content against each other.

Graham Richardson -The Effect of Chemical Solutions on Pinto Bean Growth
Mills E. Godwin High School

This experiment aims to extend the germination rate of pinto beans since beans are a food that can be grown in most countries and find which chemicals can

grow the largest beans. Testing different chemicals on pinto beans aims to discover which beans germinate fastest and grow the tallest, learn which chemical leads to the fastest germination, and learn any other behavioral or color changes on the plants. The hypothesis for the experiment was “If the nitrogen solution is used on pinto beans, then that group of beans will grow the tallest.” There is a control to the experiment water, which was chosen because if pinto beans were grown, water would be the most cost-efficient way of growing pinto beans. Every three days four groups of 25 pinto beans were watered with four different solutions, potassium, phosphorus, nitrogen, and water. Each plant set was watered with 800mL of water mixed with 1.7 grams of the specific chemical. This process was completed for 30 days. Safety was taken by wearing gloves and clothes that covered exposed skin while experimenting. The data was significant compared to the control and the null hypothesis was rejected along with Nitrogen having the tallest set of pinto beans. The results were due to the fact that the chemicals used had beneficial effects on the pinto beans such as faster germination rates and taller growth.

Lucas Royster -The Effect of *Poa pratensis* Height on Soil Temperature
Mills E. Godwin High School

The purpose of this experiment is to determine the effect of the height of *Poa pratensis* on soil temperature. Plants release amounts of carbon into the soil during respiration. That carbon is used to feed many kinds of beneficial microbes. When the plant dies, these microbes metabolize the carbon, releasing more carbon into the atmosphere. Since a higher temperature increases enzymatic activity, the higher the temperature the more carbon is being released into the atmosphere due to increased microbial activity. Differing plant heights may cool the soil more effectively than others, reducing carbon release that would add to global warming. 125 cups were filled with 63.75 grams of soil and had 10 grams of seeds planted 2 centimeters deep and left for 8 weeks in an enclosure with 2 growth lights, being watered with 30 mL of water daily at the same time. After 8 weeks, the grass was cut to heights of 10, 8, 6, 4, and 2 cm. After a day, the soil temperature was measured and recorded. It was hypothesized that taller heights of *P. pratensis* would result in cooler soil temperatures. The results showed that taller plant heights had lower soil temperatures due to the soil temperature decreasing from 10 cm (18.0 °C) to 2 cm (19.8 °C). A t-test was performed showing that the data was significant for every comparison. The results did support the research hypothesis. The results are due to plants cooling their surroundings through evaporation and transpiration.

Shruthi Tirunahari -The Effect of Overcrowding on Crop Production
Mills E. Godwin High School

The purpose of this research was to determine if there was a significant difference between the heights of wheat crops grown under different colors of LED lighting. Two-inch planter pots housed each group of sixteen wheat crops (control, red, blue, purple). They were grown for five weeks and received water until they were saturated at least twice a week, and plant heights were recorded each week in centimeters. The resulting averages on week five for each group included 28.838 centimeters for control, 26.925 centimeters for red, 27.319 centimeters for blue, and 27.294 centimeters for purple. To analyze the data, a single-factor ANOVA statistical analysis test was run, however, the results indicated that there was not a significant difference between the groups. The alpha-value of .05 was used and the resulting p-value was .502. The research hypothesis stated that if wheat plants are exposed to blue lighting as compared to red, purple, and normal white lighting, then they will germinate and grow faster. Therefore, the research did not support the research hypothesis and there were no statistically significant differences between the groups. This study focused on implementing agricultural advancements to optimize crop growth.

Botany - B

First Place

Thomas Bill, Leslie Yang - Urine as a Nitrogen Source for *Lepidium sativum*:
Creation of a Novel Synthetic Solid Urine Testing Model and Product
Harrisonburg High School

The Haber-Bosch Process produces most of the world's ammonia-based fertilizers. Due to the inherent explosive nature of ammonium nitrate, the requisite fossil fuels, and the massive carbon dioxide (CO₂) emissions, it is time to evaluate other sources of nitrogen to feed the world's 8 billion people. Previously, the use of human urine as a fertilizer has been depicted, but this concept is challenging on many levels. This paper describes a novel method to create, test, and store solid synthetic urine as a fertilizer for *Lepidium sativum* (garden cress). Garden cress fertilized with synthetic urine had a significantly higher yield in mass than the control group. Synthetic urine in its solid, powdered form decreases storage and transportation issues compared with large volumes of liquid urine. This study demonstrates that solid urine is shelf-stable due to its bacteriostatic properties and low hygroscopicity. Fertilizing with human urine can

provide a renewable resource in agricultural systems, reducing the need for the Haber Bosch Process and its consequences.

Second Place

Abigael Ellis - The Effect of Applying Various Types of Sunscreens to the Leaves of Devil's Ivy Plants on the Number of Discolored (Brown Spotted/Yellowed) Leaves, the Number of Fallen Leaves, and the Length of the Roots, Over Time
Clover Hill High School

The purpose of this experiment was to determine the effects of physical and chemical sunscreen on living tissue. The initial hypothesis was that chemical sunscreen would cause the most discolored and fallen leaves as well as loss of root growth for Pothos or Devil's Ivy plants. To test the hypothesis, 30 Pothos plants were split into three groups of 10 (control, chemical, and physical) and sprayed with their corresponding sunscreen periodically over the course of four weeks. Each plant's number of discolored and fallen leaves were counted and each plant's root growth was measured in centimeters. The results showed that the plants treated with chemical sunscreen had the most discolored and fallen leaves but that plants treated with physical sunscreen had the least root growth. The null hypothesis was rejected, and the initial hypothesis was partially supported.

Third Place

Taylor Bupp -The Effect of Chemical Fertilizer vs. Rabbit Manure on Grass Growth
Clover Hill High School

The purpose of this experiment was to determine the effect of rabbit manure on grass growth. The problem that was addressed in this experiment was the harmful toxins apparent in commonly used chemical fertilizers which pollute the environment. Consequently, it would be resourceful to find a natural fertilizer that provides the same essential nutrients without the damaging side effects. The research hypothesis was that adding rabbit manure would increase grass growth more than adding chemical fertilizer. In this experiment, ironite chemical fertilizer and rabbit manure were added to grass plants and watered daily. They were measured after two weeks, and rabbit manure displayed the greatest amount of plant growth as well as the greatest number of seeds that sprouted. In the end, the null hypothesis was rejected, and the results of the experiment supported the research hypothesis.

Andrew Dang - The Effect of Different Macronutrient Supplements on Radish Plant Growth

Mills E. Godwin High School

The purpose of this experiment was to determine the effects of different macronutrient supplements on radish plant growth. Nitrogen, phosphorus, and potassium are the three essential nutrients found in fertilizers. By studying the most beneficial nutrients to plant growth, those who work in the agricultural industry can learn how to maximize the quality of their plants by incorporating those nutrients into their fertilizers. It was hypothesized that if nitrogen, phosphorus, and potassium supplements were given to radish plants, the nitrogen supplement would cause the plants to grow the tallest. After germinating and planting 100 radish seedlings, each seedling was watered once every three days. Additionally, once every three days 25 plants received the nitrogen supplement, 25 received the phosphorus supplement, 25 received the potassium supplement, and 25 did not receive any supplement. The data was collected after three weeks and the results showed that the nitrogen group had the highest average height, the phosphorus group had a slightly lower average height, and the potassium group's average height was barely higher than the control group's average height. At a level of significance of 0.05, the t-tests comparing the three supplement groups to the control group showed that the data from the nitrogen and phosphorus groups was statistically significant and rejected the null hypothesis, while the data from the potassium group was not statistically significant and did not reject the null hypothesis. This was likely because nitrogen and phosphorus play much more important roles in plant development and growth than potassium.

Victoria Alberti - The Effect of Compliments and Insults on Plant Growth

Mills E. Godwin High School

The purpose of this research was to explore how words affect growth. The main idea was to show how by complementing and insulting plants, there would be a significant difference between their growth. The research hypothesis was that if the plants are complimented, then their growth will be the largest. Plant growth represents human development, while the IV models how people talk to each other. The rationale was to show how words have significant effect, applying to bullying, and how it affects people. The four groups had 25 beans each. The groups were as follows: Plants complimented, plants insulted, plants complimented and insulted, and plants not complimented or insulted (this was the control, in which the plants received no talking.) The beans were kept inside

a greenhouse then given the same environmental factors. The groups were talked to individually every day for 10 minutes. Every 3 days, the height of each plant was measured, then the mean was calculated from each group. It was found that the plants complimented grew larger compared to the others. When an inferential stats test was run, it was calculated that $p < 0.05$ for the complimented plants. Complimented vs. insulted plants was also $p < 0.05$. The mean growth of the groups was also different, with a 2.3 cm (about 0.91 in) difference between complimented vs the control. In more specifics, the insulted plants grew 0.8 cm (about 0.31 in) less than the control. The reason for these results is words, and how they specifically influenced each group.

Nicholas Dewitt - The Effect of Drought on the Emergence Rate of *Glycine max*
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if drought had a significant effect on the emergence rate of soybeans. This study was conducted using three treatment groups (10 ml, 20 ml, 40 ml) over two experimental runs. Using non-initial and initial watering for the experimental runs this data was analyzed by tracking the days to emergence and percent germination to see if the amount of drought affected the number of days it took for my soybean seeds to emerge. Performing a two-way ANOVA test, with an alpha level of .05, analyzing the days to germination between having an initial watering and non-initial watering which generated a p-value of 8.77×10^{-6} for initial watering and .001 for non-initial watering indicating that the data was significant. Moreover, using a chi square analyzing percent germination and concluded that non-initial watering, which had a p-value of 4.83×10^{-5} , had a significant difference from the expected count. The findings led to the conclusion that the amount of water soybeans receive impacts how long they take to germinate or if they germinate at all. It also implies that initial and non-initial watering have an impact on the emergence rate. This investigation supported this hypothesis, which indicated that if *Glycine max* is subjected to various levels of drought, the time of emergence will decrease, as evidenced by this study's results. In summation, drought affects plant growth by decreasing the plants' germination rate and overall growth.

Lindley Crosby - The Effect of Agricultural Pesticides on the Early Growth and Development of *Z. mays*
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine whether or not agricultural pesticides

have a negative impact on the root and coleoptile growth of *Z. mays* seeds. Five seeds were grown per resealable bag, with a damp paper towel to initiate germination. The paper towels were soaked in three concentrations of Monterey Garden Insect Spray, 32%, 60%, and 100%, along with a control group of only water. After one week, the length of the root and coleoptile of the 140 seeds were measured using ImageJ. Those results were evaluated using a one-sample ANOVA test with an alpha level set at .05, which returned a p-value of .0005 for root length and 8.75×10^{-11} for coleoptile length. A post-hoc Tukey test revealed Dmin values of .712 for root length and .316 for coleoptile length. Those values determined that root growth showed statistically significant difference in all seed groups except between 0% and 100% of pesticide, while coleoptile growth showed statistically significant difference in all seed groups except between 60% and 100% of pesticide. Even though the data was shown to be significant, the research hypothesis, which stated that if *Z. mays* seeds are exposed to varying amounts of pesticide during germination, then the seeds exposed to the highest concentration of pesticide will have the shortest root growth and shortest coleoptile, was not supported. In conclusion, pesticide exposure to *Z. mays* seeds significantly affected the early growth of their coleoptile and roots.

Audrey Collins - Testing Honey's Antifungal Properties on the Development of Tomato Wilt (*Fusarium oxysporum*)
Central Virginia Governor's School for Science and Technology

The purpose of this experiment was to test if honey could be used as a non-chemical fungicide when introduced to *F. oxysporum*. In order to do this, 1-month-old Black Krim tomato plants were given 0.05g of honey in 15mL of water and later given cultured *F. oxysporum* then allowed to grow for three weeks. After the three weeks, the plants were weighed, dehydrated, and weighed again. The mass difference from this dehydration was used to show the hydration level of the plant and therefore how affected it was by the honey and/or fungus. A single-factor ANOVA test was then run using an alpha value of .05 with hydration data from the experimental group and three controls: plants given only honey, only fungus, and nothing at all. The resulting p-value of .008 prompted a Post Hoc Tukey Test which revealed a D-min value of .029. Compared to the mean differences of 0.0105g between the Honey Fungus and Honey No Fungus groups, 0.0131g between the Honey No Fungus and Fungus No Honey groups, and 0.003g between the Honey Fungus and Honey No Fungus groups, this resulted in no statistical significance between the experimental and fungal control group. This did not support the research hypothesis that there would be difference between these groups. While this

experiment resulted in a lack of notable statistical significance, it has potential to be greatly important in the future for fungicide research.

BOT - Botany – C

First Place

Chloe Miles - How Organic and Synthetic Insecticides Affect Marigold Growth
Collegiate

Pesticides are used to protect plants and produce from outside disturbances such as insects, diseases, and weeds. Synthetic pesticides are substances coming from plants, animals, bacteria, or minerals that have been chemically modified by humans. They have been known to cause cancer and organ failure in humans and increase the growth of those organisms being treated with them, as demonstrated by a study conducted by Walker (1963) (as cited by Cope, 1966). Though thorough searches were attempted using numerous search guidelines, research regarding organic pesticides could not be found. Organic pesticides are composed of naturally occurring substances from the earth. This research examined the effects of organic and synthetic pesticides on marigold growth. Marigolds germinate quickly, making them a good choice for this experiment as it only lasts three months. The null hypothesis was that there would be no significant difference in the growth of marigolds between groups of insecticides. The alternate hypothesis was that there would be a significant difference in the growth of marigolds between groups of insecticides. There were five levels of the independent variable: insecticides. The first was the control, which contains no insecticides. The second and third were both organic active ingredients in insecticides: spinosad and diatomaceous earth 100%. The fourth and fifth were both synthetic active ingredients in insecticides: gamma-cyhalothrin and zeta-cypermethrin. The dependent variable was the marigold growth categorized by total sprout count per level, total leaf count per level, and height of the tallest sprout in cm per pot per level. The levels of marigolds were treated with their respective insecticide as prescribed by the directions of each insecticide and all levels were watered twice a week. Measurements were taken on five different dates. Fifteen Analysis of Variance Tests (ANOVA) to find if there were statistically significant differences between levels. Significant differences between levels were found, and the null hypothesis was rejected. The data collected found that marigolds treated with synthetic insecticides had significantly more sprouts, leaves, and taller sprouts than marigolds treated with organic insecticides. The data in this research suggests that synthetic insecticides do increase the growth of plants

more than organic insecticides and untreated plants; however, they do pose a threat to the health of humans, the plants being treated, and organisms such as insects and other animals around them.

Second Place

Natalie Harwood - Mycorrhizal Fungi and their Relationship with Plant Productivity and Carbon Decomposition
Collegiate

Mycorrhizal fungi are underground fungi that serve as small thread-like webs that connect and assist the growth and germination of plants while also helping them reach deep water, and nutrients, while also sending chemical signals between plants allowing them to communicate with each other. These fungi are known for helping boost the growth of plants, helping them thrive and grow at a faster rate. Research on the effects of fungi on plant growth has begun to ask if mycorrhizal fungi promote carbon sequestration because of their growth-boosting abilities. Carbon sequestration is the process of taking and storing carbon in the atmosphere deep into the ground keeping it out of the atmosphere. Carbon sequestration is key to fighting climate change as it continues to rise in sea levels, temperatures, and precipitation. Possibly using these fungi to boost the growth of plants to allow for an increased rate of carbon sequestration to help combat climate change. Through my experimentation of testing three different levels of soil, 12 pots of each of the three levels of independent variables, one with a full dose of mycorrhizae fungi, a half dose, and a level with no fungi to see their effect on the growth on the plants for myself. This growth was recorded for a month, measured eight separate times, and the measurements were recorded each time. I tested the growth of cosmos seeds and how mycorrhizae would affect the growth and growth rate of the plants to see just how much this fungus affects the growth. Through this research, the data showed that the effect of mycorrhizae fungi was significant, with a p-value of $< .00001$. This significance of data could also be seen in the root growth of the plants as well. This data overall reflects the data from other researchers while also answering the question of how much of an effect these fungi have on plant growth. By boosting growth these fungi can be used as a way to boost carbon sequestration by boosting growth using it to help tackle the challenge of climate change and its effects that accompany it.

Third Place

Madison Hensley - Comparing Sister Cropping to Various Fertilizers Indoor and Outdoor

Chesapeake Bay Governor's School

Sister cropping is an indigenous mixed planting system that uses beans as a source of nitrogen fertilizer, squash as a natural pesticide, and corn for the beans to grow up along the stalk. This method is a natural fertilizer that has no runoff and increases biodiversity in a garden area, whereas modern fertilizers create runoff which causes eutrophication in the Chesapeake Bay. This study investigated the use of sister cropping, 10-10-10 fertilizer, liquid nitrogen fertilizer, manure, and a control of no fertilizer to measure the effects of these methods on the growth of yukon chief corn in a controlled indoor environment compared to an uncontrolled outdoor environment. The results of this experiment found that fertilizing methods ($p\text{-value} = 0.000000012$) and being grown in indoor or outdoor environments ($p\text{-value} = 0.017383$) significantly impacted overall corn growth. It was found significant that 10-10-10 fertilizer differed from sister cropping, manure, and the control while there was a difference in sister cropping in the indoor versus outdoor experiment. Due to the natural temperature fluctuations outdoors, it could have caused the variations in the data which would have affected the $p\text{-values}$. This study shows that sister cropping may provide a more natural alternative to synthetic fertilizers that could then prevent the eutrophication issue by reducing fertilizer runoff and promoting a more diverse plant structure which can help lower the number of dead zones present in the Chesapeake Bay.

Daniella Jeyasingh -The Effect of Arbuscular Mycorrhizal Fungi on *Asclepias syriaca* growth in Acidic Soil

Mills E. Godwin High School

This project, in its current iteration, stems from a plant-microbe experimentation initiative focused on understanding the impact of Arbuscular Mycorrhizal Fungi (AMF) on *Asclepias syriaca* growth in acidic soil, driven by the interest in habitat restoration within environments characterized by acidic soil. The choice of AMF was informed by the identified symbiotic relationship between *Asclepias syriaca* and acidic soil. The hypothesis inferred that the addition of 45 mL of AMF would enhance *Asclepias syriaca* growth, specifically promoting its maximum height. To investigate this, three groups were established with varying AMF levels: a control with no AMF (0 mL), one with 15 mL, and another with 45 mL of AMF inoculum. Planting pots filled with acidic soil incorporated

designated AMF amounts, and uniformly planted *Asclepias syriaca* seeds were closely monitored for germination rate, seedling height, leaf count, and visual health. Soil pH levels were tracked using pH strips to assess changes over time. Statistical analyses were conducted, revealing calculated t-values for the 0.15 mL versus the control (8.08) and the 0.15 mL versus 0.45 mL (12.20), both exceeding the table t value of 2.000. The rejection of the null hypothesis suggests statistical support for the research hypothesis. Potential explanations for the findings include variations in *Asclepias syriaca* growth influenced by different AMF levels, emphasizing the significance of symbiotic relationships in nutrient absorption. The plant's adaptability to acidic soil conditions, notably through its robust root system, might contribute to observed variations. However, potential errors could arise from environmental variables impacting plant growth, underscoring the importance of meticulous controls in future studies.

Anna Krzyzanowski - Salinity Effects on the Growth of Atlantic White Cedar *Hampton Roads Academy*

Due to global warming, glaciers and icecaps are melting causing the sea level to rise. In turn, coastal plants have been exposed to high levels of seawater that have made their way into the soil. The Atlantic White Cedar (AWC) is one of the trees affected by this rise. The AWC is a freshwater tree often found on the coast of the United States from Maine to Georgia. With the prolonged exposure to seawater experienced by these trees, many have died, resulting in ghost forests, an area full of dead trees caused by the rising sea level. A decrease in carbon sequestration due to ghost forests can cause atmospheric carbon to increase and contribute to global warming. In order to combat these ghost forests and the carbon emissions they cause; scientists have been looking for a way to make coastal freshwater trees salt tolerant. Making trees more tolerant to higher salinity would enable them to survive the rising sea levels. This research aims to study how salt affects the AWC tree's growth over 17 weeks in an attempt to create a higher salt-tolerance tree. Twenty AWC tree saplings were placed in soil planters and grown for two weeks before starting salt treatments. Ten trees were randomly selected to receive a 2 ppt salt treatment and monitored for height and diameter growth. Trees that received 2 ppt saltwater grew taller than the ones in the control group, although the control trees grew to have a wider base than those receiving the 2 ppt salt treatment.

Grihith Makineni -The Effect of Pest Control on Plants Infested by Pests.
Mills E. Godwin High School

This experiment was conducted to analyze the effect of pest control methods on the height of infested plants. Pests cause a major hole in the production of crops as close to 40% of all crops are wasted due to pest infestation. A solution would be pest control, and in the field of pest control pyrethrin (organic pesticides), ammonium sulfate (chemical pesticides), and ladybugs gave satisfactory performances. Garden cress plants were grown for one week and were provided with 266 mL of water and sunlight every day. After a week, 30 pests were placed in the pots, and a day later the plants were treated with pest control methods. After one week the height of the plants was measured and recorded. The control group in the experiment was plants with no pest control treatment. This will help compare if pest control makes a difference in plant growth. It was hypothesized that the plants treated with pyrethrin would grow taller. The results displayed that pyrethrin led to the tallest plants with a height of 31.8 cm. The standard deviation for the IV levels proposed that all the data was precise. Six t-tests were calculated for the data, and they suggested that all the data was significant. The results supported the research hypothesis that was made. The final results were caused because organic pesticides don't alter the condition of the crop after eradicating the pests. The following experiment would allow scientists to enhance pest control methods for better quality plants.

Lilly Lennon -The Effect of Soil Additive on Basil Growth
Mills E. Godwin High School

This project in its present form is the result of soil additives on basil growth. The purpose of this research was to determine which soil additive helps basil growth the most. Epsom salt, Coffee Grounds, and Eggshells were used in gardening to give nutrients to plants, and these soil additives may have a similar effect on the plant basil. Each basil seed was treated with either a teaspoon of Epsom salt, Coffee grounds, or Eggshells. The plants were allowed to grow for 3 weeks and then their height was measured in centimeters. The control used in this experiment was no soil additive. It was hypothesized that basil plants treated with Epsom salt would produce more growth than any other soil additive. The results revealed that Epsom salt grew the least on average (0.8cm) than eggshells (1.1cm), the control (1.1cm), and coffee grounds (1.0cm). A t-test was conducted on the data, and it revealed that the data was not significant for any experimental group. The results did not support the research hypothesis. It is believed that the results are likely due to

chance and not the independent variable. For future continuation, this experiment will be given more time for the plants to grow, and the types of soil additives will be investigated.

Anwitha Methari -The Effect of nutrient dense waters on height of radish microgreens.

Mills E. Godwin High School

The purpose of this experiment was to discover the effects of different nutrient dense waters on the plant growth of radish microgreens. Nowadays, microgreens are becoming more and more popular due to their nutrient content. Since nutrient dense waters are being studied more, this experiment's objective was to observe what effect they would have on plant growth. The waters were prepped two days before use to allow fermentation. The plants were grown for ten days before harvesting and height was measured every two days. The control that was applied in the experiment was plain water. A hypothesis was formulated that rice water would have the largest positive impact on plant growth. It was revealed by the results of this experiment that none of the waters had any significant difference between each other, and the height of the plants remained relatively similar. Also, rice water was proven to have the least positive effect on plant growth than the other independent variable levels, so the research hypothesis was not supported by the results. The contributions of this project prove that nutrient dense waters may not have any significant effect on plant growth of microgreens when a substrate is used, due to their short growing period. However, this experiment could be extended by studying the amount of nutrients absorbed from this water into the plant or growing them hydroponically (without substrate) to really observe their effects on microgreens.

Katelyn Melton - Administering Helium to Dandelions, White Clover, Kentucky Bluegrass, and Broadleaf Plantains to Observe Possible Herbicidal Effects

Southwest Virginia Governor's School

Invasive and unwanted species are out of control in many places around the world. Kudzu is an invasive species; it grows rapidly and has a deep root system. Chemical herbicides are frequently used; however, they aren't always effective in completely killing the plant, they can cause harm to the local flora and fauna, and even infect surrounding water sources. Research is needed on alternative herbicide methods that are effective and safer to the environment. In one study, helium was discovered to be an effective alternative herbicide to

kudzu. Does helium have the same effect on other plants? Broadleaf plantains, white clovers, dandelions, and Kentucky bluegrass were grown together in a controlled environment. All variables related to their growth were kept the same. There were six plants of each type in one group, and five groups. Two methods were used to administer the helium to the plants. Method 1 where gas was blown up into the container through the drainage holes and Method 2 where plants were taken out and blown with gas on the roots. Compressed air was used as a control in both methods (group 2 and 4) and there was a control group where no gas was administered. The growth, in centimeters, over a week was taken of all plants to monitor if the plants increased or decreased in height. The mean growth in centimeters of groups 1 and 2 (method 2), 3 (control), and 4 and 5 (method 1), is 0.9, 1.38, 1.38, 1.25, and 1.9 respectively. The two methods, both using the main control group, were tested by their growth using an ANOVA test. The p-value of Method 1 (0.1803) and Method 2 (0.3980) were greater than the alpha (0.05). This means that the mean growth of both methods was insignificant. It was found that helium has no herbicidal effects on other plants besides Kudzu. Helium is a nonrenewable resource and would not be for widespread use; however, more investigation into its herbicidal properties to kudzu could be useful. Studies should continue to be conducted on alternative herbicides.

Botany - D

First Place

Meraal Zahra -The Effect of Organic and Inorganic Fertilizers in Field Corn Plants Vitamin C Concentration

Central Virginia Governor's School for Science and Technology

The purpose of my research was to determine whether different plant fertilizers impacted vitamin C concentration in field corn plants. My study maintained three groups: a control group (no fertilizer) and two experimental groups (organic fertilizer and inorganic fertilizer groups). Plants were stored in a Conviron plant chamber during the duration of a 6-week growing period. Once they reached the end of their growing period, a calibration test was performed to receive a specific value to measure how much vitamin C was being calculated per drop. After the value was received, a titration was needed to calculate the content of vitamin C per group. After gathering all data, a single factor ANOVA test resulted in a P-value of .6 with an alpha value of .05, meaning this was not a statistically significant outcome. The research hypothesis stating that if both chemical and organic fertilizers are applied to

corn plants, then those exposed to the chemical fertilizers will have lower Vitamin C levels than the organic fertilizer group but higher than those with no fertilizer, was not supported by the data, since there was no significant difference in the amount of vitamin C present in the plants. Information in this study could still be utilized in future research concerning agricultural production and the nutritional values that contribute to this important and global sector.

Second Place

Aditi Vasudev -The Effect of Hydroponic Nutrient Additives on Tomato Growth
Mills E Godwin High School

This experiment aimed to find the effects of different nutrient additives on tomato growth when grown hydroponically. The purpose was to study various levels of potassium and the effect of fruits and vegetables on tomato plants. The control in this experiment was distilled water. The IV levels, apples, broccoli, and bananas were tested by making a five percent ratio with distilled water for each. It was hypothesized that the tomato plants with broccoli as the nutrient solution would grow the tallest. This was hypothesized because broccoli had the middle level of potassium, and too much or too little K are both not good for plants. The experiment was conducted by constructing 20 hydroponic machines and using the IV levels to create four nutrient solutions. The tomato seeds were planted, and their mean height was collected after 30 days. The hypothesis was supported by the data because the results of the experiment showed that the tomato plants with the broccoli grew the tallest. Three t-tests were conducted with the data recorded. It was found that the data was significant, and the null hypothesis was rejected, supporting the research hypothesis. A possible explanation for why the middle level of potassium, the broccoli, was the best for the plant could be due to potassium deficiency from the apple solution and nutrient imbalances from the banana solution. An extension of this research could be conducted with different nutrient additives or with a different test plant.

Third Place

Leighton Nelson -The Effect of Bioremediating Ammonium Nitrate on *Lemna minor*
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine whether or not different levels of ammonium nitrate could be remediated by *Lemna minor*. To do this, a control

group of 4.6mL ammonium nitrate (without duckweed) was compared to two other concentration groups containing 4.6mL and 9.2mL of ammonium nitrate, with each concentration group containing seven samples. When setting up the concentrations, 40mL of the ammonium nitrate solution was diluted with 20mL of water before being added to 600mL of spring water for each sample. In regard to the remediation of ammonium, there was statistical significance when tested with a one-way ANOVA ($\alpha = .05$, $p\text{-value} = 1.41 \times 10^{-9}$). The post-hoc Tukey test value D_{min} of 6.4 indicated that the significance was between the control with no duckweed to the experimental groups, but there was no difference between the experimental groups. The means for the 4.6mL, 9.2mL, and 4.6mL Control groups were measured with ammonium: (42.11mg/L, 58.85mg/L, and 12.67mg/L, respectively) and nitrate: (-33.87mg/L, 327.02mg/L, and -2.62mg/L, respectively). After using a one-way ANOVA for the nitrate group, it was determined to have no significance ($\alpha = .05$, $p\text{-value} = .072$). The research hypothesis: if *Lemna minor* was put into spring water containing ammonium nitrate solution, then it would bioremediate the ammonium and nitrate ions from the fertilizer, was not supported. In conclusion, *Lemna minor* had no significant effect on the phytoremediation of ammonium nitrate solution.

Honorable Mention

Liam Murphy -The Effect of Water Placement on Root Growth
Mills E Godwin High School

Hydrotropism is the growth of roots towards or away from water. The purpose of this experiment was to determine how much roots are attracted towards water. We wanted to be able to see if this could be used for larger scale projects. The hypothesis that was used was if 50 ml water is placed to the right of the plant the roots will grow in that direction. The experiment was conducted using 100 radish plants over the course of 30 days. The experiment had four IV levels, the control being the plants being watered regularly with water. The plants were watered in specific ways to control the growth of the root. The results showed that the water did have a significant effect on the growth of the roots. The control group did not have any significant results but gave a baseline to compare the rest of the independent variables. While some of the Independent variable levels (IV) did not show significant results this could be fixed with further experiments. The artificial lights that were used may also need some adjustments. The cost of the experiment was way higher than expected and could be fixed. The results of the experiment lead me to believe that this could be used to a higher level. For example, tree roots that interfere with the infrastructure with houses and pipes.

Honorable Mention

Srivedha Veerapaneni -The Effect of Banana Stem Covering on Ripening Time
Mills E Godwin High School

This experiment was conducted to find the effect of banana stem covering on ripening time. Currently, bananas are very popular fruits that are sold worldwide and affect many economies. Although they are very popular, there is still a surplus of bananas that are not being sold due to the fact that consumers want healthier foods. Covering the banana stem to prevent ripening would be a way to solve this problem while also satisfying customers' needs. The banana stems were wrapped individually and then pictures were taken of each banana for seven days. The control in this experiment was the banana with no cover. It was hypothesized that the plastic wrap would result in the least ripe bananas of the 4 tested independent variables. The results showed that the plastic wrap and aluminum foil worked better than the control and that the wet paper towel worked better than the plastic wrap and aluminum foil. The chi-square test conducted showed that the data was statistically significant, meaning the results were most likely due to the independent variable rather than chance. The results did not support the research hypothesis. It is believed that the results are due to the fact that the wet paper towel might have been thicker when wrapped. Further studies can be conducted on how much the thickness of the material might affect the ripening and if different thicknesses of the material act differently.

Honorable Mention

Gauri Vinjanampati -The Effect of Rhizobia on *Vigna radiata* Growth in Acidified Soil
Mills E Godwin High School

The purpose of this study was to determine the effect of rhizobia on *Vigna radiata* growth in acidified soil. The IV levels included normal, double, and triple rhizobia inoculant doses, with no rhizobia as the control as it was the standard that other IV levels were compared to. Testing the limits of rhizobacteria was critical for application in agriculture through its plant-growth promoting abilities. Eighteen *Vigna radiata* seeds were planted in acidic soil (pH four) in identically sized containers. Each seed was given 6 ml of water and 6 hours of light daily. Plant height was recorded weekly for four weeks. It was hypothesized that if rhizobia dose was tripled, then *Vigna radiata* would undergo the greatest growth. Most growth was seen in the normal dose group and the double dose group had the least growth. Standard deviation comparisons showed that the

no rhizobia dose data was most precise, and the normal rhizobia dose data was least precise. The t-test revealed that the data was statistically insignificant, except for the double dose vs. triple dose, indicating that data for all tests but the exception was due to chance and not the independent variable. Therefore, the research hypothesis was not supported. These results were impacted by measurement errors and inconsistent watering and exposure to light. The potential negative effect of pH four on rhizobia efficiency likely also impacted results. Further study could explore the effect of rhizobia co-inoculation on plant growth and the increased biodiversity as a result of rhizobia treatment.

Abigail Olihnenco -The Effect of Relative Humidity on Thyme Growth
Mills E Godwin High School

The purpose of this experiment was to find the effects of different creations of relative humidity on the growth of thyme. The thyme plants were grown in a humid environment caused by either just misting them or by misting and covering them with plastic bags. The control that was used for the experiment was not creating a humid environment but just watering them. It was hypothesized that thyme plants that were misted and covered in plastic bags would grow taller than just misting and no misting. The results revealed that plants grown in a humid environment caused by misting and covering them with plastic bags grew .3 cm more than just misting and .7 cm more than the ones not grown in a humid environment. A t-test was done on the data, and it revealed that the data was significant for misting and using plastic bags versus the control and misting versus misting and using plastic bags. The results rejected the null hypothesis. The third t-test was done on misting versus the control, and it revealed that the data was not significant. This result was not able to reject the null hypothesis. It is believed that the results are due to the fact that misting and using plastic bags is the best way to grow plants in a humid environment.

Megan Nyffeler – The Effect of Herbicides on Photosynthetic Rate
Mills E Godwin High School

This project is currently an experiment within plant sciences on how different common herbicides affect photosynthetic rates of green algae beads. The purpose of this experiment is to determine the effect of herbicides on photosynthesis. This experiment was conducted to help people who take care

of lawns or farms better understand different herbicides and their effects. Homeowners and farmers may use herbicides to remove unwanted weeds across the land. The algae beads were placed in a bicarbonate indicator solution that also contained an herbicide, either Glyphosate, Atrazine, or 2,4-dichlorophenoxyacetic Acid (also known as 2,4-D). The solutions were then left under a light to allow photosynthesis to occur before the samples were analyzed in a spectrophotometer. The control for this experiment is water to ensure that the data is accurate. This project's research hypothesis states that if Atrazine is the herbicide used, then it will inhibit photosynthesis the most. The data did not support the research hypothesis. At the end of this experiment, it was proven that Glyphosate had the greatest inhibition of photosynthesis by the algae beads. Based on the inferential stats tests calculated, Glyphosate caused the most inhibition of photosynthesis, while 2,4-D caused the least inhibition of photosynthesis.

Vimridh Vasudev – Exploring the Impact of Arbuscular Mycorrhizal Fungi Presence on Spring Onion Growth Under Environmental Stress Factors
Mills E Godwin High School

This experimental study aimed to explore the impact of arbuscular mycorrhizal fungi (AMF) on spring onion growth under varied environmental stressors: temperature, drought, salinity, and control conditions. Because abiotic stressors, including temperature, drought, and salinity, critically affect plant productivity, the experiment sought to understand AMF's role in enhancing plant resilience. It was hypothesized that AMF-inoculated spring onions would exhibit superior growth compared to non-inoculated trials across all stress conditions, with the most significant effect occurring between salinity stress. The procedure involved planting spring onions, subjecting them to simulated stress conditions and measuring leaf lengths after three weeks. The experimental design included eight independent variable levels, two of each abiotic stressor, separated by the presence or absence of AMF. The study utilized statistical analyses, including t-tests, to evaluate the impact of AMF. All comparisons of abiotic stressors in the presence and absence of AMF, except the control group comparison, were statistically significant, indicating the results were due to the independent variable and not chance or error. Results indicated that AMF significantly enhanced spring onion growth, particularly evident in salinity stress conditions, supporting the research hypothesis, as the AMF-treated plants demonstrated a 54.003% average increase in growth compared to non-AMF inoculated plants. The experiment supported existing journal articles, emphasizing AMF's beneficial role in nutrient uptake and plant

growth enhancement. While acknowledging potential variables like soil composition, the study underscores AMF's potential in enhancing plant resilience and granting scientists opportunities for further research to cultivate more resilient crops.

CHM – Chemistry – A

First Place

Shayni Gogineni -The Effect of Testing the Glucose Levels in Four Different Types of Fruit, Before and After Cooking the Fruits, on the Resultant Glucose Levels in each Type of Fruit
Clover Hill High School

The purpose of this experiment was to determine the effect of testing the glucose levels in four different types of fruit, before and after the fruits were cooked, on the resultant glucose levels in each type of fruit. High intake of sugar from fruits can lead to several health-related problems and can negatively affect the human body. Finding which fruit is healthier to cook with will provide better options of food for people with health issues such as diabetes which is caused by increase of glucose levels. To measure the glucose levels, a refractometer was used. The four levels of independent variables were strawberry, avocado, apple, and banana. Small, star cylinder shapes were cut out of each fruit and were carefully weighed. Each fruit piece went through the before cooking and after cooking process. The glucose levels were recorded in a data table, and this process was repeated until each level had 30 complete trials. The combined average mean of the glucose levels in each fruit were 0.12 °Bx for the strawberries, 0.18 °Bx for apples, 0.37 °Bx for bananas, and -0.23 °Bx for avocados. After the data was collected, the null hypothesis of a significant difference was tested using an ANOVA test, and the null hypothesis was rejected. The research hypothesis of this experiment was that avocado would contain less glucose both before and after cooking than the other fruits would. This was supported.

Second Place

Folasade Archer -The Effect of Using Baking Powder versus Different Types of Yeast, as a Leavening Agent, on the Height and Density of Madeleines
Clover Hill High School

Leavening agents have been around for years with yeast dating all the way back

to the ancient Egyptians. Leavening agents have a broad range of uses and applications in baking that finding how they affected food is important information for bakers and cooks. In this experiment, finding how well each leavener produced air bubbles by tracking their height would add to this knowledge. To find this information, the French tea cake called a madeleine was the test subject to see how leaveners would affect such a small dessert. The three leaveners that were used were double-acting baking powder, instant yeast, and active yeast. The double-acting baking powder was the control agent. When the research was conducted for this experiment, the hypothesis was: If the three leaveners - active yeast, instant yeast, and double acting baking powder - were put into a madeleine, instant yeast would yield the greatest height. When conducting the experiment, the recipe for the madeleines was altered for the yeast agents so they would have the right conditions to rise. Many would assume that yeast would tower over the double-acting baking powder from many witnessing how tall yeast-risen bread can become when rising inside or outside the oven. However, after baking, the results for height were always followed by the tallest to shortest: double-acting baking powder, instant yeast, then active yeast. When running the ANOVA significance test, its results came out to reject the null hypothesis. However, the data did not support the research hypothesis, since the instant yeast was second in the rank of height. It comes as a shock to those that the yeast did not produce a taller madeleine compared to the double-acting baking powder. However, many do not know the complete composition of many leaveners or how they produce the air bubbles needed in baked goods for them to understand these results.

Third Place

Riley Fulcher -The Effect on the Carbon Dioxide Levels of *Saccharomyces cerevisiae* when Used with Various Sugars

Central Virginia Governor's School for Science and Technology

The purpose of this study is to determine how yeast responds to sugar substitutes compared to standard sugar. Ten milliliters of white sugar, brown sugar, and stevia will be added to a yeast suspension, which consists of 100 milliliters of tap water at 30 degrees Celsius and ten grams of active-dry yeast. My experiment will also have a control group. After sitting for five minutes, each sample will be measured for the amount of carbon dioxide produced using a Vernier carbon dioxide probe. The results of this study shows that the type of sugar used in a yeast suspension has an effect on the amount of carbon dioxide produced. A one-way ANOVA statistical test was run to determine this. A Tukey test was then run to further distinguish between the significance of the groups.

The p-value given was .002 which is less than the alpha value of .05. My research hypothesis that states stevia will produce the most carbon dioxide when mixed with a yeast suspension was not supported by my data, as white sugar produced the most. Finding a sugar substitute that can properly activate yeast can lead to a major benefit of those trying to live a healthier lifestyle.

Honorable Mention

Abigail Lynn Flores -The Effect of Painting Oak Wood with Three Different Colors of Acrylic Paint, and Exposing the Paintings to Sunlight, Artificial Light, and No Light on the Difference in RGB Values Over Time
Clover Hill High School

This experiment addresses the concern of the effects of light exposure on the maintenance of conditions of acrylic paint when exposed to various forms of light. The hypothesis of the experiment was as follows: If red, blue, and yellow acrylic paints were exposed to no light, LED light, and sunlight, the groups exposed to sunlight would yield the greatest change in RGB values of the acrylic paint over time. Groups of popsicle sticks, painted with blue, yellow, and red acrylic paint, were held under LED light and sunlight over time to compare the effects of the respective light exposures. To measure this effect, the RGB values of the popsicle sticks were recorded and later compared with each other. The results of the experiment showed little to no deviations from the control groups. However, the green color values of the blue groups were seen to yield the greatest change in value. The null hypothesis was not rejected as the data did support the research hypothesis.

Honorable Mention

Meredith Greer -The Effect of Using Cage Free, Free Range, Pasture-Raised, and Caged Eggs in a Cupcake Recipe on the Resultant Density of the Cupcake
Clover Hill High School

The purpose of this experiment was to determine which type of egg from various production systems would yield the least dense cupcakes. Knowing the outcome from using different eggs in baking can help consumers choose the best products to purchase when grocery shopping. The initial research hypothesis stated that if caged, cage-free, free range, and pasture raised chicken eggs were used in cupcake recipes, the cupcakes baked with pasture raised eggs would yield the least density. To test this hypothesis, 10 trials of cupcakes were baked for every level, with each trial containing 8 cupcakes. The

baked cupcakes were cut to the same size using a biscuit cutter and the mass of each was measured to determine the density of each cupcake. The control group, or the caged eggs group, yielded cupcakes with an average density of 0.46 g/cm³. The cupcakes baked with cage free eggs had an average density of 0.43 g/cm³. The cupcakes baked with free range eggs had an average density of 0.42 g/cm³. The cupcakes baked with pasture raised eggs had an average density of 0.40 g/cm³. After all the data was collected, an ANOVA test was conducted to determine the statistical significance. The ANOVA test showed that the result was significant, and therefore the null hypothesis was rejected. The experiment data showed that the cupcakes baked with pasture raised eggs had the lowest density. Thus, the hypothesis was supported.

Honorable Mention

Kellan Dore - The Effect of Amount of Time Exposed to Ultraviolet Light on Acrylic Paint Drying Time
Clover Hill High School

The question that prompted the experiment was if exposure to UV light while paint is drying could reduce the time it takes to dry? The hypothesis was that if acrylic paint was exposed to UV light, then the drying time would decrease. The procedure of the experiment began when the resources were gathered. A machine was made using a paint shield and servo motor along with sheets of poster board to drag acrylic paint along the poster board. The cans of paint were shaken, and a syringe was used to extract the paint. The paint was then exposed to UV light for 5, 10, and 15 seconds. After a small delay the paint was poured into the machine and dragged until no streaks remained. Humidity and temperature were documented for each trial. The distance that the paint traveled was measured and divided by the speed of the motor in centimeters per second in order to find the drying time in seconds. The mean drying time of the control group was 11.3 seconds. After being exposed to UV light for 5 seconds the mean drying time of the paint was 11.9 seconds. Following 10 seconds of UV light exposure decreased the mean drying time of acrylic paint to 11.0 seconds. When UV light was shone on acrylic paint for 15 seconds the mean drying time was 10.1 seconds. The results were analyzed using a two factor ANOVA test to determine if the results were statistically significant. The P-value was less than 0.00001 which suggested that the results were statistically significant. The null hypothesis was rejected, and the research hypothesis was supported because the drying time trended downward as time exposure to UV light increased.

Clara Heath -The Effect of Microwave Popcorn Popping Time and Power Level on the Percentage of Popped, Unpopped and Burned Kernels
Clover Hill High School

The purpose of this experiment was to find the combination of microwave time and power level to achieve the lowest percentage of unpopped and burned kernels. The hypothesis was: the level 1:40/60% (microwave time in minutes/ power level in percentage) would result in the most unpopped kernels, the level 3:00/100% would result in the most burned kernels, and the level 2:20/80% would achieve the least burned and unpopped kernels. The independent variables were microwave time and power level. The levels of the independent variables were: 1:40/100%, 2:00/100%, 2:20/100%, 2:40/100%, 3:00/100%, 1:40/80%, 2:00/80%, 2:20/80%, 2:40/80%, 3:00/80%, 1:40/60%, 2:00/60%, 2:20/60%, 2:40/60%, 3:00/60%. The level 1:40/100% was used as the control. Twenty trials were conducted at each level for a total of 300 trials. In order to find the optimal popping condition, 300 bags of microwave popcorn were popped, for each bag, every kernel was removed from the bag, evaluated, sorted, and counted. The kernels were each classified as either popped, unpopped, or burned. The numbers of popped, unpopped, and burned kernels per bag were converted into percentages, then the mean percentages for each classification for each level were calculated. The null hypothesis of no significant difference was tested using a One-Way ANOVA test with 0.05 level of significance, the null hypothesis was rejected. The research hypothesis was mainly supported. The level 2:00/100% yielded the highest mean percentage of popped kernels, 62.67%. In general, as the time and power level increased, the percentage of burned kernels increased and the percentage of unpopped kernels decreased. The opposite was also true, as the time and power level decreased, the percentage of unpopped kernels increased and the percentage of burned kernels decreased.

Nikolai Bukin -The Effect of Heating on Emission of Microplastics
Mills E Godwin High School

In America, plastic containers are constantly used for storing and reheating takeout food. This experiment was designed to study the emission of harmful particles during reheating. The number of particles released was measured by filling a container with water, heating it, and measuring the amount of microplastics. It was hypothesized that if HDPE 2 high-density Polyethylene is used, it would release the greatest amount of microplastics. Goggles and gloves were gathered to protect eyes and hands. Twenty-five, four-ounce containers of

each material were gathered. (PP 5 polypropylene, HDPE 2 high-density polyethylene, PET 1 Polyethylene terephthalate, and glass.) All containers were filled with 2 ounces of water. Ten containers were microwaved at a time for 3:30 seconds and the remaining 5 were microwaved for 1:45 to account for heat distribution. After heating, the containers were removed with tongs, set to cool until room temperature, and tested using a microplastic measuring tool. This step was repeated for all materials. Safety measures required for this experiment are wearing goggles to protect your eyes from bubbling plastics and gloves to protect your hands from hot plastic and plastic shards. The quantitative data of the amount of microplastics released was measured and analyzed for the mean and compared to the control. Data was then organized into a data table detailing microplastic release (ppm). A significant difference in water quality was noted between the control and the levels of independent variables with PP5 Polypropylene containers leading to the highest parts per million quantities.

CHM - Chemistry -B

First Place

Anya Mathew -The Effect of Various Novel Adsorbents on Methylene Blue Adsorption

Mills E. Godwin High School

Adsorbents are widely used in various applications, including water and air purification, gas mask filters, medical treatments, industrial processes, and analytical chemistry. While adsorbents have many applications, there is limited research on globally sustainable adsorbents that can be applied to the environment and population safely. The purpose of this experiment was to assess the adsorption capacities of three different solutes: Green Tea Extract, Activated Charcoal, and Ascorbate Calcium. These served as the independent variables. The control, containing no solutes, was a methylene blue solution. The hypothesis posited that Ascorbate Calcium would exhibit the highest adsorption capacity, followed by Activated Charcoal and Green Tea Extract. To test this hypothesis, various levels of the independent variable were employed, while the dependent variable was the absorbance percentage of the methylene blue solution. The experiment involved measuring the absorbance percentage using a SpectroVis instrument calibrated to detect the blue color associated with methylene blue. The results revealed a statistically significant linear relationship between solute concentration and methylene blue adsorption, supporting the

initial hypothesis. The study's findings can be applied to environmental contexts, such as oil spill cleanup, as well as to address health concerns related to tar build-up in the lungs.

Second Place

Manasvi Kannure - The Effect of Aloe Vera on Inhibition of Steel Corrosion
Mills E. Godwin High School

The purpose of this experiment was to figure out the correlation between increasing concentrations of Aloe Vera on corrosion in mild steel. A research hypothesis was formed that if the concentration of Aloe Vera increases, then the overall weight loss will decrease. The rationale was that if optimum concentrations are found out, then it will lead to more efficient usage of organic inhibitors. Seventy grams of the powder was soaked in 700 ml of ethanol for 5 days. It was filtered using a coffee filter and evaporated. Concentrations of 0% (control), 1%, 3%, and 5% of Aloe Vera were made using 0.3 M HCl and the extract. Thirty milliliters of a solution was poured into 25 petri dishes. Hundred steel coupons were cut and weighed using a balance in grams and then were immersed in the petri dishes. After 7 days the weight loss was recorded in grams. There was no significant difference between IV levels 1%, 3%, and 5%, however there was a significant difference between IV levels vs. 0%. This implied that Aloe Vera inhibited corrosion but increasing concentrations did not make a difference in weight loss. This rejected the research hypothesis. The results may have been due to a short experimental time or the small differences in concentration. Other studies exhibited that increasing concentrations of extract led to higher corrosion inhibition efficiency which did not support our research. Further research would include the effects of using different methods of Aloe Vera extraction on corrosion inhibition.

Third Place

Aditya Modi - Effect of Various Teas and Remedies on Neutralizing Stomach Acid
Mills E. Godwin High School

This project aimed to determine which substance could make lemon juice the least acidic, indicating which is the most beneficial for stomach acid reflux, gastroesophageal reflux disease, and/or heartburn. It also investigated the effects of different teas and remedies on neutralizing stomach acid. To test the effectiveness of these remedies, milk, green tea, peppermint tea, aloe vera juice, baking soda water, and Alka Seltzer were added to lemon juice, a substance with

a pH similar to stomach acid, and the amount of pH increase was measured. The consumption of a variety of day-to-day substances has become popularized to bring relief to the body from those stomach issues.

The hypothesis formulated was, if green tea is inserted into lemon juice, then the pH of lemon juice will be neutralized the most, due to high pH level. 20mL of each independent variable was inserted into 20mL of lemon juice while being mixed and the pH of the solution was measured using a pH probe. Alka Seltzer served as the control because it is frequently ingested to raise stomach pH.

The results indicated that baking soda water made the solution the least acidic and green tea made it the most acidic, showing the hypothesis was insignificant and not supported; the t-tests were significant. Based on the pH of the solution the results are determined. Baking soda was identified as the most basic or alkaline substance and increased the pH of lemon juice the most. The research could lead to studies of substances to avoid consuming to help neutralize the pH of stomach acid.

Honorable Mention

Ruby Hoerter - The Concentration of Vitamin C In Non-Organic and Organic Fruits and Vegetables

Southwest Virginia Governor's School

Organic fruits and vegetables are known to be environmentally safe due to the lack of chemicals and pesticides used on the crops. However, whether organic fruits and vegetables are more nutrient-dense than their non-organic variants is still a mystery. The consumer typically strives to buy the more nutrient-dense option of them all. If organic foods can have results that point to being “better” for consumers, they will know which one to purchase for them and their families. This experiment strived to answer whether organic fruits and vegetables—in this case, kiwi, broccoli, and oranges—contained a higher concentration of Vitamin C than non-organic fruits and vegetables of that kind. In order to complete this experiment, a titration using sodium thiosulfate, $\text{Na}_2\text{S}_2\text{O}_3$, and potassium iodate, KIO_3 , was used. The fruit or vegetable was ground to make a powder-type substance for better use. The null hypothesis for this experiment stated that the organic orange, broccoli, and kiwi would have the same Vitamin C concentration as the non-organic variants. The alternate hypothesis stated that the vitamin C concentrations of organic fruits and vegetables would be higher. The joint mean Vitamin C content of the organic fruits and vegetables was 61.9 mg, while the joint mean Vitamin C content of the non-organic fruits and vegetables was 34.6 mg. By performing a matched pairs t-test, the p-value was 0.0118. Using the standard alpha of 0.05, there is enough evidence to support that the organic

orange, kiwi, and broccoli contained a higher Vitamin C concentration than the non-organic orange, kiwi, and broccoli. If this project were to be adapted further in the future, using fruits and vegetables during different seasons or switching up the fruits or vegetables used may prove to be beneficial in determining whether or not organic food is more nutrient-dense than non-organic food. Another adaptation that could be useful is to test the produce for different nutrients such as calcium and sugar.

Honorable Mention

Cole Martin - The Effect of Ripeness of Banana (Days Since Purchase) on the Height of Banana Bread
Clover Hill High School

The purpose of the experiment was to determine the effect of the ripeness of bananas on the height a banana bread rises. There is very little research on the effect of the pH of a solution on its interaction with leavening agents, and bakers may be able to use the results of the experiment to better understand the chemical reactions occurring in their foods. The research hypothesis was that the height of the banana bread would increase as the ripeness of the banana increased, and the bananas that were 12 days old would result in the tallest bread loaf. Green bananas were purchased, and their ripeness was measured in the number of days after purchase. The bananas were included in a banana bread mixture, which was evenly distributed into 5 236-mL Souper Cube containers. The containers were placed in an oven for 40 minutes and, after the time had passed, were taken out of the oven. The finished banana breads were taken out of the containers, and their heights were measured using a ruler and a level. The mean heights of the breads using bananas 2, 4, 6, 8, 10, and 12 days after purchase were 54.9 mm, 54.6 mm, 56.0 mm, 55.7 mm, 54.8 mm, and 55.2 mm, respectively. The null hypothesis was not rejected. The research hypothesis was not supported by the data.

Anaya Kalore - The Effect of Different Soils on Metal Corrosion
Mills E. Godwin High School

The purpose of this experiment was to determine if different soil types influence metal corrosion rates. If the corrosive effects of soil are understood, preventative measures can be taken and will aid in avoiding safety hazards and in reducing costs. It was hypothesized that metal in a clay soil environment will corrode more than when exposed to the other soil types. Steel pieces were placed in sand,

garden, or clay soil. As the control, some pieces stayed without soil. The metal pieces were kept in their respective soil type to corrode for three weeks, and every week, their weight was measured in milligrams. The results showed that the steel exposed to clay soil corroded more compared to all the independent variable levels. The average weight loss in sandy soil was 2 mg less than that in clay soil. However, sandy soil caused much more mass loss than garden soil. The control only resulted in an average of 2 mg mass lost. Metal corrosion measured in weight loss was compared utilizing t-tests, and it revealed significant differences in the effect of soil types on metal corrosion, except in sandy soil versus clay soil. The results supported the research hypothesis, which means that clay soil caused the highest corrosion. Additionally, there were some outliers that were outside the 2 SD range. It is believed that the results are due to clay soil displaying high water retention and moisture content, and sandy soil having less water and being acidic.

Avani Kaur - The Effect of Natural Phenolic Compounds on Reducing Oxidative Stress

Mills E. Godwin High School

Purpose: Oxidative stress is caused by redox dysregulation between free radicals and antioxidants, damaging cellular components. This phenomenon has been implicated in the pathophysiology of various diseases, notably cancer and neurodegenerative conditions, which are becoming more prevalent due to environmental pollutants and unhealthy lifestyle choices. Therefore, the objective of this experiment was to identify a natural phenolic compound exhibiting potency in reducing oxidative stress. Methods: Cyclic Voltammetry (CV), an electrochemical technique, was utilized to measure the compound's oxidation potential. This experiment employed a conventional three-electrode cell and provided information on the redox behavior of molecules by analyzing anodic peaks of the graph. The observed redox potentials were analyzed versus a Ag/NO_3 reference electrode, serving as a control. It was hypothesized that curcumin would exhibit the smallest oxidation potential. Results: The results revealed that epigallocatechin gallate (EGCG) was easiest to oxidize and most effective in alleviating oxidative stress. T-tests were conducted and demonstrated that the data was both statistically significant and insignificant. The results did not support the research hypothesis. Conclusion: It is believed that the results occurred due to structural differences. Curcumin's complex structure and susceptibility to degradation through autooxidation potentially generated pro-oxidant effects. Resveratrol, with two hydroxyl groups and a less-intricate conjugation system than curcumin, demonstrates greater effectiveness. In

contrast, cinnamic acid has a small and simple structure, contributing to its lower oxidation potential than resveratrol. Finally, EGCG's significant impact on mitigating oxidative stress is attributed to its moderate conjugation system and more functional groups with electron-donating capabilities.

Zainah Malik - The Effect of Lipase on the Degradation of Different Microplastics
Mills E. Godwin High School

This experiment was conducted to understand the effects of the hydrolytic enzyme lipase on various microplastics. Microplastics, measuring under 5 mm, resist decomposition and resist decomposition, accumulating in beaches, oceans, and human bloodstream, posing health risks. Enzymatic degradation, as shown by the recently discovered PETase which breaks down PET, a plastic previously known to be completely resistant to degradation, presents a promising solution to enhance microplastic removal and address the global plastic pollution crisis. A lipase solution was created and then placed in test tubes with 25 pieces of each microplastic, and then were allowed to incubate for a week. The degradation of the microplastic was examined by measuring the concentration of microplastic found in each solution using the Vernier SpectroVis. There was no control in this experiment as the lipase solution needed a substance to react with, and water could not be used as it was incorporated into the solution. It was hypothesized that there would be a higher concentration of broken down polyurethane (PU) in the lipase solutions. The results showed that polystyrene (PS) degraded the most. A t-test was performed on the data and revealed that the data was not significant and failed to reject the null hypothesis. Additionally, the results did not support the research hypothesis. This was due to the possibility of each plastic being coated with additives that prevent biodegradation or a weak hydrolytic enzyme that could not efficiently break down the esterase bonds between the carboxylic acid and alcohol groups.

CHM - Chemistry -C

First Place

Neha Pillai -The Effect of Road Salt on the Corrosion of Automobile Parts
Mills E Godwin High School

The purpose of this project was to learn the effects of water-dissolved road salt on metal corrosion. It was important for car owners to understand how these solutions can be detrimental to the health of the underframe of their cars, and the results of

this experiment showed the extent of that damage. The experiment began with creating solutions with salinity levels of 4.00%, 4.50%, and 5.00%. The fourth independent variable level was a control using distilled water. Twenty-five Petri dishes were filled per solution and samples of mild steel were weighed and each assigned to a Petri dish where they were submerged fully. The samples were kept in stable condition and sat for three weeks. Once reached, the mass of the steel samples was recorded and the change in mass was calculated, revealing the results within this experiment. The results revealed that a salinity level of 5.00% was the most damaging while distilled water was the least. The hypothesis was that if the salinity level of the solutions is 5.00%, then the steel samples will have the most amount of corrosion demonstrated by the change in mass. The data supported the hypothesis as the 5.00% group had the highest average change in mass with 0.20 g. The T-test data for each level had shown that most of the data was insignificant except for the 4.00% vs. 4.50% group. The reasoning behind the results was likely due to a variety of human error and other sources of issue.

Second Place

Ryan Sagini -The Effect of Various Chemical Agents on the Permeability of Latex Gloves

Clover Hill High School

The sole purpose of this experiment is to address the effect of various chemical agents, used in the medical field, on the permeability of latex gloves. Skin irritation due to exposure of chemicals to skin affects approximately 4–11 out of every 1000 workers in the medical field. This is caused by the permeation of chemicals through latex gloves. In this experiment, 180 gloves were filled up with 175 milliliters of water. 6 groups of 30 gloves were created. Those groups were individually exposed to Eugenol, Hydrogen Peroxide, Sodium Hypochlorite, Potassium Hydroxide, 5% NaOCl, plus the control, and hung up on a shoe rack. The mass of each glove on the first day was recorded to be 175 grams and was entered into the data table. These glove weights were recorded every 3 days for 12 days. To measure the permeability of these latex gloves, the difference in the mean mass from Day 1 to Day 9 was recorded. The mean variations in glove mass from Day 1 to Day 9 were 19.3 grams for eugenol, 22.2 grams for potassium hydroxide, 23.5 grams for hydrogen peroxide, 50.4 grams for Sodium Hypochlorite, 25.4 grams for 5% NaOCl, and 20.5 grams for the control. The various chemicals, Eugenol, Hydrogen Peroxide, Sodium Hypochlorite, Potassium Hydroxide, and 5% NaOCl had all affected the glove permeability, showing Sodium Hypochlorite as the most detrimental. The research hypothesis states that Eugenol, Hydrogen Peroxide, and Potassium Hydroxide would have no effect on the resulting

permeability of the latex gloves, but Sodium Hypochlorite and 5%NaOCl would increase the resulting permeability. This was not supported and the null hypothesis was rejected.

Third Place

Julianne Woo -The Effect of Chlorine Concentration of the Water that Hair is Soaked in on the Change in Color of the Hair
Clover Hill High School

Pool chlorine, if not in moderation, can be extremely detrimental to both hair strength and color. Chlorine can easily penetrate the hair's outer layers and strip it of its natural oils, which ultimately can lead to significant changes to its visual properties. Within this experiment, strands of hair were soaked in varying chlorine concentrations to determine the extent of damage chlorine can have to the discoloration of hair pigment if soaked for a prolonged period of time. This was to simulate the long-term effects of exposure to chlorine in pools. The hypothesis was that the varying chlorine concentrations at each independent variable level would all have more drastic effects on the discoloration of the red RGB value than any of the other RGB values, discoloration of the red RGB value increasing as the chlorine concentration in each independent variable level increased. To test this hypothesis, 120 hair strands were photographed and analyzed by an RGB analyzer. Then, 30 strands of hair were submerged into each chlorine concentration, 0%, 0.00125%, 0.0025%, and 0.00375%, for 5 days and then left to dry for 24 hours. Afterwards, the hairs were once again photographed and analyzed by an RGB analyzer to determine results and any changes that occurred. The change in RGB value of the hairs generally indicated a growing numerical intensity of RGB values as the chlorine concentration increased. Ultimately, the experiment's results indicated that the null hypothesis was rejected and that the research hypothesis was not supported by the data.

Tanvi Nareddy -The Effect of UVB Light Radiation on the Photodegradation of β -carotene
Mills E Godwin High School

The purpose of this study was to investigate the behavior of β -carotene when exposed to UVB light for different periods of time. UVB light is a major carcinogen, mainly responsible for melanoma-type skin cancer. The light hits directly into human skin and disarranges the nitrogenous bases in DNA present in the cells of human skin. A compound present in human skin is β -carotene indicating the

carotenoid may possess photoprotection properties, which can protect against melanoma-type skin cancer. The rationale for this experiment was how a carcinogen for skin cancer impacts a compound present in the skin and its potential uses in skin protection. The research hypothesis was if β -carotene was placed under UVB light for 3 hours, then it would photodegrade the most. The control was distilled water under UVB light running with each independent variable level to compare to the β -carotene solution. The experiment was completed by extracting β -carotene from carrots using pectinase and filtering, then placed under UVB light for the respective independent variable levels and measured after every independent variable level. Results show the mean absorption, in absorption units (AU), went from 1.999 AU to 1.206 AU to 1.495 AU then to 1.316 AU. An inferential and descriptive statistical test indicated the results were significant except for the independent variable levels of 1 hour vs. 3 hours and the results were not due to chance. These results may have been achieved because UVB light promoted the chemical change of β -carotene and broke the polymer chains present in the carotenoid which reduced the molecular weight overall, causing photodegradation.

Vidhi Shah -The Effect of Various Sweeteners, Used in a Kombucha Recipe, on the pH of the Kombucha, Over Time
Clover Hill High School

The purpose of this experiment was to determine the effect on kombucha pH when using replacement sweeteners: monk fruit sweetener and raw honey. Monk fruit sweetener and raw honey both have many more health benefits than cane sugar, and when used in kombucha, they could amplify the healing properties present in kombucha, leading to a better alternative for cane sugar kombucha. The hypothesis was: If raw honey and monk fruit sugar were used in kombucha instead of cane sugar, then the monk fruit sugar would have a lower pH level than cane sugar, and the raw honey would have a pH level higher than the cane sugar. The pH of the various kombuchas was tested overtime, during the fermentation process, which lasted fourteen days. The three levels of independent variables were cane sugar (control), monk fruit sweetener, and raw honey. The pH of each kombucha was recorded in a data table, and this process was repeated until each level had 10 complete trials. The control kombucha, the cane sugar kombucha, had a mean pH of 3.170. The kombucha made using monk fruit sweetener produced a mean pH of 3.290 and the raw honey kombucha had a mean pH of 3.170. After the data was collected, a One-Way ANOVA test with a 0.05 level of significance was conducted to test if the data was statistically significant. The null hypothesis was not rejected, and the experimental hypothesis was not supported.

The data proved that monk fruit sweetener and raw honey are suitable replacements for cane sugar in kombucha.

Kyler Strang -The Effect of Battery Charge on Battery Reactivity
Arlington Career Center

The purpose of this experiment was to test the effect of battery charge levels on battery reactivity temperature in order to understand safety and performance implications. Battery reactivity is what happens when a battery is short circuited. This is important because it is a common problem in many industries that can lead to a major safety risk called thermal runaway which can cause fires and explosions. It was hypothesized that a lithium-ion battery charged to 4 amps will be more reactive than one charged to 2 amps. To conduct this experiment, rechargeable lithium-ion batteries were charged to 0, 2, and 4 amps as measured by a multimeter. The batteries were shorted with a steel wire and then a copper wire. Temperature was measured with an infrared thermometer. During the experiment, the wires heated up instead of the battery. Also, the multimeter was unable to read the amperage. Therefore, no data could be collected. These results are inconclusive about the hypothesis. Recommended future experiments should include connecting a device that draws power, such as a light, to the battery.

Disha Talajia - Nutritional Content of Bananas Over Periods of Time
Southwest Virginia Governor's School

This study set out to find how much sugar and calcium were in fresh bananas. The experiment assessed changes in sugar and calcium levels using a standard refractometer and the titration method. Bananas were purchased from the same retailer in an unripe stage and then ripened at room temperature. Bananas from the same batch were tested for sugar and calcium content at various ripening stages. The results showed that the average calcium content increased from 0.724 mg/1g in unripe bananas to 0.932 mg/1g in ripe bananas and 1.11 mg/1g in overripe bananas. However, after further analysis, no significant evidence was found to suggest that as bananas ripen over time, the calcium content also increases. Meanwhile, the average sugar content significantly increased from 0.128 g/1g in unripe bananas to 0.262 g/1g in ripe bananas but decreased slightly from ripe to overripe bananas. The results of this investigation provide consumers with information regarding the nutritional worth of bananas at different stages of ripening.

COM - Computational Biology - A

First Place

Ashrita Gandhari - Minimizing In-Vitro Fertilization Failures by Utilizing Artificial Intelligence to Evaluate the Health of Human Embryos

Thomas Jefferson High School for Science and Technology

The quality of the transferred embryo is the crucial factor that impacts the success of the in-vitro fertilization (IVF) treatment. Embryologists and other related clinicians are responsible for deciding which embryo should be chosen for transfer in the IVF process. They are faced with a life-changing task that could potentially lead to failure of conception, and they definitely should ensure their final diagnoses are accurate. Alternative tools used to make this paramount decision are limited, subjective, time-consuming, and extremely expensive. However, an embryologist's skills, coupled with the precision and accuracy of an automated evaluation system, could improve IVF success rates by ensuring consistent results. Employing modern technologies, such as artificial intelligence(AI), is the deciding factor between providing accurate or inaccurate results. This project, LetoHealth, utilizes prevalent convolutional neural network (CNN) architectures to distinguish embryo health and quality at 113 hours post insemination (hpi) on day 5 of culturation based on its morphology. In this study, I assessed ResNET-50, Xception, and multi-layered CNN architecture built from scratch; Xception performed the best with a validation accuracy of 0.98, precision of 0.98, and a loss of 0.05 among these. To enhance accessibility to LetoHealth's human embryo 1-5 grading system based on morphology, I developed a web-based user interface hosted on cloud. This application enables embryologists and clinicians to analyze real-world clinical data.

Connor Beasley - Metagenomic Analysis of the Microbial Biodiversity in Soil of Mountain Balds in Appalachia

Southwest Virginia Governor's School

This study sought to find out whether the soil microbiomes present at mountain balds are unique; specifically, whether the diversity of microbes present is higher than expected. Soil samples were collected from 3 sites in the southern Appalachian Mountains: Whitetop Mountain, Buzzard Rock, and a site proximal to Mount Rogers, all located in Grayson County, VA. From each site, 3 samples were collected from the top 5 cm of soil. The soil was then extracted with MP Biomedicals' FastDNA™ soil kit. DNA was sent to Illumina for sequencing; the only sequenceable DNA was from all 3 samples from Whitetop and 1 sample from Mount Rogers. Data were then

analyzed with Galaxy, a web-based software which has several bioinformatic tools and programs; a novel workflow was created to analyze the data. Alpha diversity for available samples were averaged, with a mean of 7.388 +/- 0.0754 (SE). This mean was compared, via t-test, to a public benchmark for the Shannon diversity index, 4.5, due to it being known as an unusually high biodiversity value. The calculated p-value was calculated to be less than 0.0001. Greater understanding of the biodiversity of soil organisms that can better make arguments for the protection and further study of mountain balds. Future studies should increase sample size, ensure quality of DNA, and investigate the potential of novel lineages.

Taarun Ganesh - In Silico Design of a Multi-epitope-based Vaccine against the Rocio Virus *Individual*

The Rocio virus is a mosquito-borne flavivirus that causes headache, fever, confusion, and fatal neurological symptoms. Currently, no licensed vaccine or antiviral therapy is available for this virus. Here, we used an in-silico approach to design a multi-epitope vaccine candidate against structural and non-structural proteins of this Brazilian virus. An epitope is the minimal antigenic component that elicits a specific immune response. Using bioinformatics methods, 30 T-cell and B-cell epitopes were selected based on antigenicity, allergenicity, and toxicity. The delivery mechanism of vaccines is also a critical part of eliciting a potent immune response. This study explored both the M13 bacteriophage display system, which fused the surface protein PIII to the epitope with a flexible linker, and the E. coli-based delivery system, where all of the epitopes were connected with different linkers, resulting in an overall vaccine length of 584 amino acids. Molecular docking was performed against two toll-like receptors to analyze the binding ability of the vaccine construct. The final vaccine candidate was antigenic, non-allergenic, and induced a robust immune response, which was predicted using an immune simulation study. In the E. coli delivery system, codon optimization and in silico cloning were performed to obtain a high level of protein expression. In conclusion, this approach allows for the rapid generation and display of epitopes, which is safer than live-attenuated vaccines. However, further validation of the candidate is required through in vitro and in vivo experiments to assess the stability and immunogenicity against the Rocio virus.

Shriya Jaddu - SeizAlert: A Deep-Learning Enabled System for Non-Invasive Pre-Ictal Seizure Prediction
Individual

Twenty-three million worldwide suffer from drug-resistant epilepsy (DRE). The unpredictability of seizure occurrences causes safety issues (e.g., driving) as well as social concerns (e.g., gatherings), restricting the lifestyles of DRE patients. Surgical solutions such as Deep Brain Stimulation that minimize seizures are very expensive, unreliable, and invasive. EEG-based solutions that predict seizures are impractical for 24-hour patient use. Hence, a non-invasive, cost-effective, and practical seizure prediction solution has remained elusive thus far. SeizAlert is a novel system that alerts DRE patients of upcoming seizures up to two hours before onset. SeizAlert comprised a system with a wearable device and a mobile application. The wearable device continuously sends patient physiological data to the mobile app, enabling seizure predictions. The mobile app included a CNN-BiLSTM model trained on a diverse set of epileptic patient physiological data. Transfer learning was further utilized to personalize and optimize predictions for individual patients. In addition, the system also had an RNN-LSTM model that predicts and confirms dysarthria, providing an optional “second opinion”. The system with a general deep learning model trained with epileptic patient physiological data achieved prediction accuracies of 91.94%. To improve performance further, personalization (further training) was applied to the general model using patient-specific data, increasing accuracies of up to 97%. Separately, a “second opinion” audio model trained on dysarthria data provided an accuracy of 98.75%. SeizAlert trained with physiological and physical data offered the ability to predict upcoming seizures. Personalization of the deep learning models offered significantly improved prediction accuracies. This research offers the first affordable, non-invasive, and practical seizure prediction system that can significantly improve the quality of life of 23 million DRE patients.

Sidh Jaddu - Investigating the Factors Affecting the Spread of the Opioid Epidemic Using Machine Learning
Individual

In 2010, there were 21,089 opioid-involved overdose deaths in the United States alone, and by 2021, that number had nearly quadrupled to an astonishing 80,411 opioid-involved overdose deaths, becoming a major epidemic. Opioid-related deaths impact people of all backgrounds but some attributes such as a specific age, race, sex, occupation, education, or underlying condition make them more prone to the

opioid epidemic. The goal of this project was to employ advanced AI technologies and identify attributes that increase susceptibility to this epidemic. This project used a Random Forest classification model that was trained on a diverse dataset for opioid-overdose related deaths. SHapley Additive exPlanations (SHAP) module was applied to identify the key attributes that contributed to these deaths. A Long Short-Term Memory network was further utilized to project the future rate of growth of the opioid epidemic and how the key attributes contribute to this growth. Random Forest model trained with opioid-related death data performed with an accuracy of 96.61%. SHAP applied to this model identified several attributes such as age range and education to be most associated with opioid-related deaths. Finally, Long-Short Term Memory (LSTM) models projected the increase in growth of the epidemic due to these key attributes. For example, the opioid epidemic growth for individuals with a high school or GED degree is 44.45% and the growth for the remaining population is 29.68%. The Random Forest model with SHAP and the LSTM model for the opioid-related deaths confirmed with high accuracy that certain attributes and their sub-attributes affect the opioid-related deaths more than others; for example, individuals with only a high school or GED degree are more likely to be impacted by the opioid epidemic. Given these findings, governments and public health agencies should institute policies to target susceptible populations.

COM - Computational Biology - B

First Place

Yashvir Sabharwal - NephroNet: A Novel Program for Identifying Renal Cell Carcinoma and Generating Synthetic Training Images with Convolutional Neural Networks and Diffusion Models

Individual

Renal cell carcinoma (RCC) is a type of cancer that originates in the kidneys and is the most common type of kidney cancer in adults. It can be classified into several subtypes, including clear cell RCC, papillary RCC, and chromophobe RCC. In this study, an artificial intelligence framework was developed and trained for classifying different subtypes of RCC using ResNet-18, a convolutional neural network that is widely used for image classification tasks. The model was trained on a dataset of RCC histopathology images, which consisted of digital whole-slide images of RCC surgical resections. The performance of the trained model was evaluated using several metrics and achieved an overall accuracy of 96%. In addition, diffusion models were used to generate original images of RCC surgical resection slides, called NephroNet. Diffusion

models are a class of generative models capable of synthesizing high-quality images from noise. Several diffusers were trained on a dataset of RCC images and were used to generate a series of original images that resembled RCC surgical resection slides, all within the span of fewer than four seconds. The generated images were visually realistic and could be used for creating datasets, testing the performance of image analysis algorithms, and training medical professionals. Overall, this study demonstrates the potential of artificial intelligence for classifying and generating RCC images, respectively. These methods could be useful for improving the diagnosis and treatment of RCC and other types of cancer, as they provide a more efficient and accurate way of analyzing and generating images.

Second Place

Brennan Shea -The Effect of Various Mutation Rates in an AI Pathfinding Experiment on Number of Generations Until Path to the Finish Line was Found

Clover Hill High School

Abstract

The purpose of this experiment was to determine which mutation rate, when given to a group of pathfinding Artificial Intelligence (AI), would result in them solving a premade maze using the least number of generations. Knowing this information would allow for people training pathfinding AI to get a consistently higher skill level in their AI when used for various problem solving . This, in turn, would allow for the AI to be better used in their practical applications, such as finding the best route to a certain point on a map to another, or figuring out what is the best escape method from a burning building. To measure which mutation rate would most positively affect the generations taken by the AI to find the end of the maze, a precoded AI program was run 100 times while set to each mutation rate. The mutation rate of 1/30 managed to get through the maze with an average of 3.7 generations used, while the control group 1/20 got through the maze with an average of 3.8. The mutation rates of 1/10 and 1/5 got through the maze with average generation counts of 4.8 and 13.6, respectively. After the data was collected, an ANOVA test was conducted to check if the data was statistically significant. The results of the conducted ANOVA test stated that there was a statistically significant difference between the four levels of independent variable because the p value was less than the level of significance being tested ($\alpha = 0.05$). It was hypothesized that out of the mutation rates 1/30, 1/20 (the control), 1/10, and 1/5, the smallest mutation rate (1/30) would end up yielding the best results. This was supported.

Third Place

Rohit Kulkarni - Adversarially-Driven Generation of De Novo Proteins for Therapeutic Drug Design

Freedom High School

Proteins are critical components of life that have shown promising results as synthetic medications. However, the process of developing therapeutic proteins requires immense amounts of time for testing and validation. Machine Learning (ML) has shown to be a powerful tool that can understand complex protein sequences, and recent research has taken advantage of its capabilities for protein design. However, limited methods exist to do so, and to the best of current literature's knowledge, existing models do not ensure that output proteins are both feasible enough to prevent unnecessary testing of proteins and diverse enough to enable a large variety of output protein combinations. As such, this work proposes Cycle-Consistent Conditional Protein Generative Adversarial Network, or CCC-ProGAN, which utilizes secondary structure and primary structure design objectives in order to produce peptide-based therapeutics for specific applications. Key losses are mathematically defined for optimization in protein generation. After conditioning, CCC-ProGAN is evaluated on a test dataset of 65 samples and 15 randomly generated proteins, showing that CCC-ProGAN is a good candidate for protein generation.

Yashvanth Singamaneni - Anisotropic Protein Secretions: Using Computer Vision to reveal insights into macrophages infected with Mycobacterium Tuberculosis

Individual

For decades, researchers have tried to study bone marrow-derived macrophages (BMDM) infected with Mycobacterium Tuberculosis (MTB). In order to analyze MTB infections, investigators have relied on a multitude of patterns of protein secretion within macrophages. One such pattern is studying the secretion of cytokines such as IL-1 β and TNF- α , two common cytokines secreted as an inflammatory response. While various computer vision algorithms exist to study isotropic secretion of cytokines, this study addresses the lack of tools present to study anisotropic secretion. A dataset, consisting of over 30 images of TNF- α secretion (primarily anisotropic) was obtained using a Plasmon-enhanced FluoroDOT assay within BMDMs. The images were analyzed using a computer vision algorithm to determine the total number of TNF- α secreting macrophages (represented by clusters) along with the amount of TNF- α secretion from each macrophage. The accuracy of the algorithm was found to be 88.5% proving to be a reliable tool while studying and analyzing elongated patterns of protein secretion. Analysis of TNF- α secretion is crucial in order to gain a better understanding of various physiological and pathological processes including cell-signaling,

inflammation, and cell defense. Future studies would gain a deeper understanding of the cell secretome process by analyzing unidirectional and anisotropic secretion patterns while enhancing the accuracy of the algorithm.

Aarush Rudraraju -The Effect of Neurotransmitters on Synaptic Plasticity:
Computational Simulation
Mills E Godwin High School

The purpose of this experiment was to observe the effects of various neurotransmitters on the synaptic plasticity of somatic neurons. Recently, there have been numerous studies conveying possible linkages of synaptic plasticity to daily lives. Exploring this concept conveys that stimuli of specific activities are released into the synapses in the brain. The stimuli are generated in the form of a neurotransmitter. Neurotransmitters can alter the synaptic plasticity in neurological complexes and discovering the most potent one can change the course of various institutions involved in breaking habits. Moreover, restraining from neurotransmitter-abundant actions could change the origination of addictions entirely. To find the most potent neurotransmitter, a brain simulation using NEURON was treated with neurotransmitter stimuli; Dopamine, Glutamate, GABA, and Serotonin. Afterward, the parameters for the brain were initialized and the simulation was run for 30 seconds each. The difference in synaptic plasticity was recorded. It was hypothesized that the brain simulation treated with Glutamine would cause the most difference in synaptic plasticity. The control of the experiment was the brain simulation where no neurotransmitters were present because it causes a standard response among synapses. Comparatively, Glutamate increased synaptic plasticity significantly more than other groups. A t-test performed on the data revealed that the results were significant and supported by the research hypothesis. The results likely occurred because Glutamate is more involved in neurological functions and triggers the memory aspect of the brain. For continued research, one could investigate the effects of different neurotransmitters on other organisms.

Aiden Sweeney - How to Detect AI in Order to Promote Academic Integrity
Chesapeake Bay Governor's School

As more students use AI to cheat and write essays for them, significant problems arise for teachers and institutions keeping their academic integrity. It is important to know which content is authentic and which is generated by AI to minimize cheating as much as possible among students and authors. One possible way to tell if a student uses AI to write their essays is by using AI detection software. An analysis of the differences between AI chatbot-generated responses and actual high school student-written

responses is needed to better understand this issue. Data from 62 high school student responses were gathered from an assignment with the results being compared to the same responses from AI chatbots. The AI chatbots used for comparison were ChatGPT, Google Gemini, Microsoft Copilot, Meta Llama 2, and Question AI. Analysis in this study indicates that student responses are considerably different from the data collected compared to the AI chatbot data, with all but one of the categories resulting in a statistically significant $p < 0.05$. The categories that were statistically different between students and AI include the average number of sentences per response, the average complex word count per sentence, the average amount of punctuation used per response, and the number of grammatical errors per response.

EGR - Engineering - A

First Place

Christopher Ashman - The Effect of Cyanoacrylate on the Elasticity Modulus of PVA Hydrogels for Cartilage Repair

Central Virginia Governor's School for Science and Technology

The purpose of this experiment was to determine the effect of cyanoacrylate on the elasticity modulus of polyvinyl alcohol hydrogels. My research hypothesis was that if the addition of different amounts of cyanoacrylate increased the elasticity modulus of polyvinyl alcohol hydrogels, then the hydrogels with cyanoacrylate would be a better substitute for cartilage repair. Three groups of different amounts of cyanoacrylate were used for this experiment: a control with no drops, and then two groups each of 2 drops and 4 drops. Ten samples per group were frozen at -18°C for 8 hours and thawed at 2.75°C for 16 hours. The different groups were tested using a compression machine to find their average stiffness in each group. The elasticity modulus was found using the formula $k = AE/L$. A single-factor ANOVA test was used to determine whether there was a significant difference between groups. The results of this analysis generated a p-value of 0.936 and compared to an alpha value of 0.05. Therefore, the hypothesis was not supported, indicating no significant difference among the three groups. The results indicated cyanoacrylate had no significant effect on the polyvinyl alcohol's elasticity modulus.

Second Place

Ava Bradshaw - Effect of Maximum Plantar Flexion Angle of a Transtibial Prosthesis on Unilateral Amputee Gait Symmetry

Central Virginia Governor's School for Science and Technology

The purpose of this research study was to determine what angle of maximum plantar flexion in a transtibial prosthetic leg corresponded to the highest gait symmetry in people with transtibial amputation (TTA). Three maximum plantar flexion angles (0 degrees, 5 degrees, and 10 degrees) were compared. Two adult males with TTA participated in this study at a local prosthetics and orthotics clinic. Each volunteer walked down a hallway while a camera recorded on each side. Vernier Video Analysis was used to calculate the position and velocity of the volunteer's hips, knees, ankles, and feet at each stage of the gait cycle. The Limb Symmetry Index (LSI) difference from 100% was calculated for each trial. The averages were 1.9470 for 0 degrees, 1.6550 for 5 degrees, and 1.3775 for 10 degrees. A lower LSI difference from 100% indicated higher gait symmetry. However, the results did not suggest statistical significance between any of the three groups. A single-factor ANOVA test was conducted on the data. This returned a p-value of .4942, which was higher than the alpha value of .05. The research hypothesis stated that if a transtibial prosthesis can plantarflex up to 10 degrees, then the gait symmetry of the unilateral amputee wearing it will be higher than if they were wearing a prosthesis that cannot flex as far. However, this was not supported by the data. The study focused on improving prosthesis alignment and comfort, and several qualitative observations were made throughout the data collection.

Third Place

Alexander Cabral -The Effect of Acoustic Horn Exit Hole Size on the Volume of the Exiting Soundwave
Clover Hill High School

The purpose of this experiment was to determine the optimum exit hole on an acoustic horn relative to its output volume. To measure this, there were four horns constructed with 800 Hz sound waves and 1600 Hz sound waves. The four levels of independent variable were 25 mm opening, 50 mm opening, 100 mm opening, and 200 mm opening. The output volume was recorded in a table and was repeated until there were 30 data inputs. The 25 mm horn (control) produced a mean volume of 70.8 dB at 800 Hz and 73.7 dB at 1600 Hz. The 50 mm horn produced a mean volume of 73.7 at 800 Hz and 69.0 dB at 1600 Hz. The 100 mm horn produced a mean volume of 81.2 dB at 800 Hz and 70.3 dB at 1600 Hz. The 200 mm horn produced a mean volume of 78.2 dB at 800 Hz and 73.5 dB at 1600 Hz. An ANOVA test was conducted to test if the data was statistically significant. The results of the conducted ANOVA test stated that there was a statistically significant difference because the p value was less than 0.05. The experimental hypothesis was that if the exit hole size on an acoustic horn was set to 25 mm, 50 mm, 100 mm, and 200 mm in diameter, then the horn with the 200 mm diameter

hole would amplify the sound to the highest volume regardless of the frequencies used. This was not supported.

Honorable Mention

Asher Barron -The Effect of Varied Load Resistance on the Power Produced by a Hydroelectric Turbine

Central Virginia Governor's School for Science and Technology

The purpose of this study was to find the most efficient level of resistance (Ω) in a hydroelectric turbine that produces the most power (mW) to improve efficiency in hydroelectric energy production. The average power produced in 15 second time intervals was measured by attaching a pressurized sink nozzle to a tube connected to the hydroelectric turbine. The results of this experiment formed a bell curve with the highest average power resulting from 75Ω . A significant difference between the different levels of resistance was supported by the results. Statistical significance was determined by a single factor ANOVA that yielded a p-value of 3.87×10^{-30} , which was smaller than the predetermined alpha value of .05. The significant difference between groups was further analyzed through a Post-hoc Tukey test that gave a Dmin value of .748. The research hypothesis that the relationship between load resistance and power production would resemble a bell curve, with a maximum point value that resembled the most efficient level of load resistance, was supported by the data collected in this experiment.

Honorable Mention

Joseph Fitzgerald -The Effect of Fiberglass on the Freeze-Thaw Change in Compressive

Strength of Pervious Concrete

Central Virginia Governor's School for Science and Technology

The purpose of this experiment was to determine if fiberglass added to pervious concrete decreased the change in compressive strength after 20 freeze-thaw cycles. The unfrozen group of 12 fiberless and 12 fibered samples was crushed after curing for 28 days. For the freeze-thaw cycles, the frozen group of fiberless and fibered samples was soaked in water for 10 seconds, then excess water was removed with pressurized air and samples were then submerged in liquid nitrogen for 10 seconds before being removed and placed into the water. All samples were tested using the same Instron load frame. The average strength of the fiberless and fibered unfrozen groups was 7.028 and 5.397 MPa respectively, and the average strength of the fiberless and fibered unfrozen groups was 6.626 and 5.100 MPa respectively, using

these values gave an average change in strength of -0.402 and -0.297 MPa for the fiberless and fibered respectively. A two-sample t-test with an alpha value of .05 and a p-value of 0.422 was used to determine if the change in compressive strength was significant. The data did not support the research hypothesis that fiberglass would decrease the change in compressive strength.

Honorable Mention

Tripp Canada -The Effect of the Leading Edge on the Lift-to-Drag-Ratio of an Airfoil
Central Virginia Governor's School for Science and Technology

The purpose of this study was to find the optimal leading edge for the greatest lift-to-drag ratio. The groups tested included both sharpened and rounded leading edges, both with variations above, at, and below the airfoil's line of camber. Each of the six groups of airfoils were tested using a fan to simulate wind, an anemometer to ensure consistent wind speeds, and force sensors to detect forces of both lift and drag. Each group had 10 trials run, resulting in 60 total trials for the experiment. Once testing was finished, an ANOVA statistical test was performed, revealing statistical significance. A p-value of 2.19×10^{-5} was found, and since that was lower than the alpha of .05, the null hypothesis was rejected. A post-hoc test further revealed significance in the groups of a sharpened leading edge above and below the line of camber. Out of the two leading groups, the sharpened leading edge below the line of camber appeared to be the most efficient, being even significantly better than the sharpened leading edge above the line of camber. These results did not support the original research hypothesis, being that the group that was predicted would perform the best performed the worst in testing. The results from testing supported that there was a significant effect that the leading edge had on the lift-to-drag ratio, and that there was a statistically superior leading-edge variation for the lift-to-drag ratio.

Cyrus Bahrambegi - Analyzing Sustainable Energy Production Using Anaerobic Cellular Respiration from Microorganisms Derived from a Modified Microbial Fuel Cell System
Individual

Research into alternative energy sources is a priority due to increasing concerns over the effects of climate change. Microbial fuel cells (MFCs) are a partial but promising solution towards combating the over-reliance on fossil fuel-based electricity. MFCs produce energy from microorganisms through anaerobic respiration, which can turn into usable electricity. An anode and cathode chamber comprise the MFC system with a membrane (Nafion 117) held within a bridge connecting the chambers. Limitations, however, have slowed the advancement of MFC development. There is a need to

demonstrate how MFCs can be altered or enhanced to increase power generation through more sustainable and cost-effective means. Utilizing new microorganisms and electrode materials has shown promise in sustainable technology. This study aims to maximize the amount of usable electricity an MFC can yield by engineering modifications to allow the system to create more energy. By using bacteria such as *Clostridium sporogenes*, *Escherichia coli* K12, *Bacillus brevis* (Cerus), and *Bacillus brevis* (Megaterium), the MFC can generate chemical energy through the anaerobic respiration of the bacteria under a controlled environment. All four bacteria were tested in the MFC system over two-week intervals, and a liquid glucose substrate was added every two days over the trial period. Each bacterium was measured at a controlled time daily to ensure a 24-hour time frame before measuring the voltage growth and checking to see if the bacteria had a constant current. Continued research into electrochemistry and bioengineering is a priority in demonstrating how MFCs can become a viable sustainable energy source.

Gabriel Cohen - An Investigation into the EEG Capabilities of the Star Wars Force Trainer II
Individual

EEG is a technology to measure electrical activity within the brain. The Star Wars Force Trainer II is a children's toy featuring EEG technology. An experiment was conducted to benchmark its capabilities via analyzing responses to previously studied conditions: closed eyes, rhythmic tapping, and reading. Analyzed parameters were the overall powers of different brain waves (alpha, beta, etc.), as well as 'Attention' and 'Meditation' (proprietary pre-processed 'eSense' parameters). Measurements from the headset were parsed once per second using a modified version of an open-source tool known as BrainwaveDetectionUtility. Two people participated, and 5 trials of 30 seconds for each condition were tested. The reading condition was not present in Participant 1. Significant changes in mean values were evaluated for each parameter individually using a Wilcoxon Signed-Rank Test. During the eyes-closed condition, both 'Attention' and 'Meditation' (eSense) saw significant increases from resting in Participant 1. Participant 2 also saw these changes, as well as significant increases in alpha waves during the eyes-closed condition. Significant increases in beta waves during the reading condition were also observed in this subject. Both changes have been noted in previous research. The 'Attention' and 'Meditation' parameters had decreased variability compared to other values, likely due to the complex pre-processing involved. In conclusion, the Force Trainer II is an affordable and rudimentary EEG device that has the ability to partially reproduce the results of prior studies. Future opportunities for research include further analysis of the factors that affect eSense parameters, as well as using a neural network to identify various actions.

Sanaya Bothra -The Effect of Transcranial Magnetic Stimulation on the Resistivity of a Fiber Based Synaptic Devices
Individual

Transcranial magnetic stimulation (TMS) therapy utilizes the induction of magnetic fields to stimulate regions of the brain and serves as an FDA-approved treatment for mental illnesses such as depression and obsessive-compulsive disorder (OCD). However, the lack of a complete accurate brain model to practice with the TMS device is a limitation to its optimization. To address this, replicas of the brain, known as brain phantoms, have been created, however, an accurate representation of TMS on neurons in this model continues to be explored. Recently, a fiber-based synaptic device that mimics neuron activity was created using PET stainless steel, which has been shown to change its resistance with increased current, discovering potential to replicate the integrate-and-fire behavior of neurons. To characterize the ability of this fiber to mimic neuronal behavior, TMS stimulations were pulsed at 25%, 50%, 75%, and 100% strengths (in amps), and the resistive response was measured. After the experiment was concluded and the data was analyzed, a pattern emerged among the three of four variables of the magnetic fields: showing excitation and damping in oscillation of the resistivity. However, this pattern was most dominant at 75% of the complete magnetic field. It was summarized that the resistive characteristics of the synaptic device resembled those of neurons when the magnetic stimulation was 75%. Typically, a waveform of the firing signals would show oscillating peaks with a steeper increase and a more shallow decrease. From the data, the pattern represents the gradual decrease of resistivity while still creating peaks at each pulse. Thus, knowing the range this neuron-like fiber displays similar behaviors is crucial for improving the accuracy of brain phantoms and implementing this device in other fields such as neuromorphic computing and neural prosthetics.

Sriman Achanta - NN-based Deep Learning Skin Cancer Classification Using Dermoscopic Images
Mills E Godwin High School

Skin cancer is a type of cancer usually caused by prolonged exposure to ultraviolet (UV) radiation. It can manifest as basal cell carcinoma, squamous cell carcinoma, merkel cell carcinoma, or melanoma. Although it has a high survival rate (>90\%), early detection and treatment of skin cancer is critical for the best chance of survival. Biopsy costs and limited availability in non-specialized clinics, particularly in rural areas, impact timely diagnosis. By implementing a low CPU and memory usage Convolutional Neural Network (CNN), a highly accurate, mobile, and automatic form of skin cancer classification can be made that makes diagnosis and classification much more

accessible for those who currently don't has access. In this paper, a model with an 89.63\% accuracy has been with lower computational complexity than other contemporary models making it possible for highly accurate CNN models to be run on mobile or remote processors or platforms with low system memory. This model can be further improved by implementing it into mobile applications and utilizing mobile cameras to allow remote, or international countries to have easy access to skin cancer diagnosis and classification.

EGR - Engineering - B

First Place

Zayd Hasan - Designing A Compact Cost-Effective Bioprinting Platform
The Mathematics and Science Academy at Ocean Lakes High School

The bioprinting field shows great promise in expanding the quality and availability of technologies that previously required large amounts of time and money to execute. In the medical field, custom implants, grafts, and testing are difficult to create and time-intensive; bioprinting reduces the effort needed by a lab by automating these tasks. However, bioprinters are currently expensive and difficult to obtain or build for a lab looking to expand its toolset. This paper explores the possibilities in designing a low-cost, modifiable, multimaterial bioprinter that maximizes use of widely available medical equipment to facilitate expanded capabilities and then evaluating its performance. The printer was tested using a dot grid test on a dry dish and was measured to be accurate to within 1000 micrometers in this test. The dot grid test consisted of printing a 4X4 grid of dyed water dots spaced at 10mm distance onto a petri dish. Each of the syringes held a different dyed solution, this evaluated multimaterial printing and accuracy. The printer was also able to be built at a sub-\$500 total price at 223.81 \$USD. Analysis revealed a significance of $p < .05$, indicating that this printer design was able to perform within 1000 microns of accuracy, thus the printer was able to print within 1000 micrometers accurately. This printer showed performance required for use in a lab setting while being fully open-source and modifiable. This shows promise is expanding the bioprinting field to more labs by lowering price and maximizing ease of use. Spreading documentation and instructions remains an important step in increasing accessibility.

Second Place

Carson Layman -The Correlation Among Rotor Diameters and Wind Turbine Power Generation

Central Virginia Governor's School for Science and Technology

It is imperative to identify more efficient methods of energy production to meet the growing global demand. Alongside other clean energy sources, harnessing the power of the wind using turbines is a clean and common way to generate electricity. The data from turbines all around the US was collected through the United States Wind Turbine Database (USWTD) and was analyzed using a linear regression. When the p-value of 2.159×10^{-8} was compared to the given alpha value of .05, the p-value was lower than the alpha value, indicating a significant difference between groups. Thus, the null hypothesis was rejected, and the alternate hypothesis was accepted. The research hypothesis which states that if the rotor diameter and power generated are measured, then there will be a positive and exponential correlation between rotor diameter and power generated, was partially supported by the collected data. Although a correlation between the two variables was extremely likely, the variables had a linear correlation instead of the predicted exponential regression. Even with its limitations, this experiment provided some valuable insight into how to increase the energy efficiency of turbines, which helps to provide energy security for the future.

Third Place

Calvin Guo - The Effect of Saltwater Fuel Cell Wall Spacing on the Generation of Energy

Central Virginia Governor's School for Science and Technology

The purpose of this research was to study the effect of saltwater fuel cell wall spacing on the generation of energy. The distance between the fuel cell walls was measured using a caliper and solidified with a hot glue gun. A solution of saltwater containing a 3.5-weight percentage of salt was used as the electrolyte. The system's energy output from 30 seconds of trials was measured using the Vernier Energy Sensor for the distances, in millimeters, of 9, 10, 11, 12, 13, 14, and 15 for 12 trials each. The average energy output measured in joules of each group from the shortest distance to the longest distance was 1.042, 1.055, 1.091, 1.159, 1.056, 1.053, and 1.024. A one-way ANOVA test resulted in a p-value of 1.15×10^{-64} , which was lower than the alpha value of .05, indicating a significant difference between groups. A post hoc Tukey test was performed to determine the significant difference between each group. The research hypothesis stated that the saltwater fuel cell wall spacing of 9 mm would generate the most energy was not supported by the data. With further development, this system can possibly serve as a reliable source of energy in the future and in many regions around the world.

Honorable Mention

Andrew Haskin - The Effect of the Application of Various Chemical Additives, onto the Golf Club, on the Distance the Ball Travels, Spin Rate, and Launch Angle
Clover Hill High School

The question that was addressed in this experiment was the effect applying various chemical additives onto the face of a golf ball would have on the outcome of the golf swing. Many chemical additives are used to give golfers certain advantages and are usually considered cheating. This was measured through the distance the ball traveled, the spin rate of the golf ball, and the launch angle of the swing. Petroleum jelly, caramel, and honey were the chemical additives used. The research hypothesis was that all additives would lead to lower ball speed and a straightened trajectory. Specifically caramel and honey would lead to a higher trajectory and longer distance. A golf swing machine was used, made by creating a pendulum using a 9 iron and wood planks. This swing machine struck the ball the same way each time, with the change being the additive applied to the club face. The experiment showed that all additives increased the launch angle, decreased distance, and differed between additives with the effect on spin. The mean for the control distance was 16.11 m, the petroleum jelly distance was 13.99m, the caramel distance was 15.97m, and the honey distance was 14.98m. The mean was 32.41° for the control launch angle, 47.00° for petroleum jelly, 36.21° for caramel, and 35.37° for honey. The mean was 2720.0 rpm for control spin rate, 2425.0 rpm for petroleum jelly, 2810.0 rpm for caramel, and 2560.0 rpm for honey. After the data was collected, 3 ANOVA tests were conducted to test if the data was statistically significant. The results of the conducted ANOVA tests stated that there was a statistically significant difference between the control and the different levels of the independent variable. These results go against the null hypothesis. An increase in distance and an increase in spin rate did not occur, however, an increase in launch angle did occur. The research hypothesis was thus partially supported.

Honorable Mention

Hannah Jansen - Impact of Toroidal Propeller Design on Unmanned Aerial Vehicle Acoustic Signature and Aerodynamic Performance
Governor's School @ Innovation Park

Unmanned aerial vehicles (UAVs) are increasingly used for many applications across a range of industries. Increased UAV usage poses a public health and environmental threat due to the annoying and potentially harmful noise they produce. This research examined the potential for toroidal propellers to decrease drone noise while maintaining or improving thrust. Using Computational Fluid Dynamics (CFD), this study assessed how variations in toroidal propeller blade minor axis length and blade count affected thrust, benchmarked against a control. CFD simulations and physical tests were

conducted on custom-designed and manufactured toroidal propellers of nine varying configurations at two different operational speeds in a custom-designed testing apparatus. A less than 5% difference was observed in CFD versus measured results for 16 of 18 tests. Longer minor axis lengths improved thrust for two- and three-blade toroidal propellers at the lower speed, but impact was negligible at the higher speed. All toroidal propeller designs demonstrated more thrust over the stock propeller at the lower speed, while three- and four-blade designs demonstrated thrust capabilities that matched or surpassed the stock propeller at the higher speed. At 10,000 RPM, all toroidal propeller designs were quieter than the stock propeller. This study confirmed reliability of CFD in propeller performance prediction and identified toroidal propellers as viable alternatives to the traditional designs due to their reduced noise levels and ability to produce equal or greater thrust. Future directions include CFD analysis at higher speeds, refinement of the testing apparatus, and evaluation of toroidal propellers in real-world UAV operations.

Honorable Mention

Larimer Laura -The Effect of Wind Speed, in a Wind Tunnel, on Amount of Damage to Model Houses, Measured by Number of House Pieces Removed During Simulated Windstorm

Clover Hill High School

The purpose of this experiment was to show the amount of damage a model house would accrue during a simulated windstorm. The hypothesis was: When 55 km/h wind speeds in a wind tunnel were applied to a model house, then seventeen pieces or more would be removed, and when 40 km/h wind speeds in a wind tunnel were applied, ten pieces or less would be removed. Model houses were made to specified dimensions using a laser cutter before being constructed and placed in a wind tunnel that was then set to a designated speed. The pieces that were removed by the windstorm were collected, then counted. While the research hypothesis was not supported due to the lack of severity of the damage on average, higher wind speeds caused more damage than lower wind speeds, and the null hypothesis was rejected.

Abhinav Gitta - Cataract Detection with Machine Learning
Individual

Cataracts are the clouding of the crystalline lens. It is crucial to detect them early to prevent permanent blindness. Cataracts are a major problem globally, and many developing nations do not have access to the equipment, or professionals needed to detect cataracts. The most common manual techniques for detecting cataracts include an ophthalmologist using a slit lamp exam or ophthalmoscope. This application of machine learning is in the form of a mobile app that uses a smartphone camera. The model was trained using fundus images of cataract and normal eyes. VGG19, Flatten, and Dense layers were added to the model. The research shows that machine learning on a mobile device can successfully classify retinal images to diagnose cataracts on an app. This app can help developing countries without widespread access to medical facilities to diagnose cataracts in an inexpensive and convenient way.

Rishab Kambham -The Effect of Electrode Location on Brain Activity
Mills E Godwin High School

The purpose of this experiment was to help disabled people gain better prosthetic limbs. This can help the wider world by allowing those who are disabled regain a sense of normalcy by providing them a prosthetic limb that functions similarly to the original limb lost. It may also further technological advancements so that people can control drones mentally in order to accomplish tasks efficiently. If electrodes are placed on different parts of the brain, then it will be able to differentiate between the electrode signals. Electrodes were placed on the experimenter's head. The experimenter performed various arm movements in order to produce signals. Those signals were split into four channels and converted into epochs in order to analyze the data more effectively. This implies that the null hypothesis was not rejected and there was no significant difference between the stated comparisons. There was no difference in the differentiation ability.

Zach Grohs -The Effects of Gasoline Additives on the Efficiency of Internal Combustion Engines
Central Virginia Governor's School for Science and Technology

Combustion engines play a crucial role in our everyday lives, serving as the driving force behind transportation, enhancing the working environment, and countless other applications. In addition, they have a profound impact on the environment. Improving the health of gasoline engines, their environmental footprint, and their efficiency, is necessary to bettering these machines and our planet. With more efficient engines requiring less run time and additives reducing harmful emissions, additives could lessen combustion engines' impact on the environment. Four distinct fuel additives were introduced to gasoline and 10 test runs for each were conducted to find any significant

enhancements in the engine's run time. Utilizing a generator engine, the additives selected were K&N, STP, Biobor EB, and 104. Results supported a noticeable increase in fuel efficiency across all additives. The average run times were as follows: 0.188 decimal hours for the control, 0.206 decimal hours for the K&N, 0.214 decimal hours for the 104, 0.212 decimal hours for the STP, and 0.204 decimal hours for the Biobor EB. A single-factor ANOVA with an alpha value of .05 and a p-value of 8.83×10^{-6} , determined statistical significance. A post-hoc Tukey test with a Dmin value of .005896 determined that there were significant differences between all the additives and the gasoline alone. Introducing these additives to fuel significantly improved the efficiency of the engine demonstrating their potential to both enhance the performance and lessen the environmental impact of internal combustion engines.

Savannah Goodwin -The Effect of Bridge Deck Structure on Resistance to Downward Loading Force

Central Virginia Governor's School for Science and Technology

The purpose of this experiment was to determine which type of bridge deck can support the most downward loading force for implementation in coastal areas affected by extreme weather. A Vernier Structures and Materials Tester was used to apply an increasing amount of force to ten sample models of each of these deck types: single slab, voided slab, and T-slab section. The average maximum forces sustained by each deck type were collected and analyzed using a single-factor ANOVA test that produced a p-value of 2.324×10^{-13} . This p-value was lower than the established alpha value of .05, indicating the results were statistically significant. A post-hoc Tukey test was then run which determined that there was significance between solid slab decks and the other two groups, with solid slab decks being able to withstand a higher amount of force on average. The research hypothesis was that if single slab decks, voided slab decks, and T-slab decks are all subjected to an increasing horizontal force, then the T-slab decks will withstand more force than the others before failure. This was not supported by the data. Overall, this experiment was beneficial in determining the reliability of deck construction on a small scale.

EGR - Engineering – C

First Place

Aashritha Penumudi - SpecuSafe: A Non-invasive and Intelligent Approach to Cervical Examinations

Individual

Cervical cancer, a leading cause of death in low- and middle-class areas, can be identified using visual inspection with acetic acid, but such speculum-based inspections can be subjective in areas without medical proficiency and a triggering process for women with a history of sexual abuse. The goal was to develop a diagnosis method to aid health professionals in low-access areas by designing an advanced prototype speculum and website with an integrated high-accuracy image-classification model. This computer-based project utilized a requested dataset of cervix images from the World Health Organization International Agency for Research on Cancer (WHO IARC) labeled with cancer status and characteristics and was used to train a supervised image classification model. The images were processed by image segmentation and masks to reduce the influence of specular reflection. The data was then augmented to diversify the data and improve prediction abilities, then run through the model which is integrated into an instructive website. SpecuSafe is a novel model speculum with integrated technologies to ease self-speculum-insertion, pH testing, lighting, and imaging. It is rechargeable with a resin-finish and smaller length/radius for comfort. The machine learning model functions with a high validation accuracy of 83%. The SpecuSafe speculum and website can save lives by detecting cervical cancer early in vulnerable populations, potentially improving with future steps of expanding the dataset and directly feeding an endoscopic camera's output to the model.

Second Place

Alexander Li - Enhancing Driving Safety Via Real Time Suppression of Radar Interference

Blacksburg High School

Automotive radar is a critical element within advanced driver assistance systems (ADASs). The real-time and accurate data provided by automotive radar systems are integral to the functionality and effectiveness of these ADAS features, making them a critical component in preventing accidents and enhancing driver safety. As the prevalence of automotive radars increases in vehicles, the interference among these systems poses a significant challenge, potentially compromising the accuracy of target detection and driving safety. An interference mitigation algorithm is necessary to minimize interference impact under highly dynamic driving conditions while adhering to strict processing time constraints. This paper introduces a real-time interference

mitigation algorithm based on compressed sensing for Frequency Modulated Continuous Wave (FMCW) radar systems. My algorithm, called Soteria, leveraging signal sparsity in the frequency-time domain, identifies and separates interference signals from intended ones using the Compressive Sampling Matching Pursuit (CoSaMP) technique. Exploiting correlations between data from adjacent time slots optimizes CoSaMP's search space, enhancing efficiency. Moreover, the algorithm employs GPU computing architecture for parallel implementation, further accelerating computation. Simulation experiments demonstrate the algorithm's capability to achieve processing times of ~10 milliseconds, surpassing state-of-the-art algorithms in enhancing target detection accuracy.

Third Place

Margaret Phillips -The Effect of Price on Cello String Performance
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine which brands of cello strings would have the greatest fit to their ideal harmonic wave. This study was conducted in a local string instrument shop in December of 2023. In this experiment, using only A strings, the string brands used consisted of Larson Soloist, Evah Pirazzi, Rondo, Jargar, Spirit, Helicore, Alphayue, Prelude, and Red Label, which were grouped into categorical groups of expensive, average price, and cheap respectfully. These A strings were tested by bowing the strings and collecting their frequencies through a Vernier Go Direct Sound sensor. Then, the frequencies were analyzed by viewing the RMSE (root mean square error) given depending on its cosine wave. Each string was tested 10 times, resulting in a total of 90 trials. This experiment used a One-way ANOVA test and a Post-hoc Tukey test in order to analyze the data in further detail. With an alpha-value of .05 and a p-value of 4.02×10^{-14} , the original null hypothesis was rejected. The original research hypothesis was not supported, which stated that the group of expensive strings; Larson Soloist, Evah Pirazzi, and Rondo, would have a greater fit, or lower RMSE number, to its respective cosine wave. It was actually found that the other string's means were lower, with Red Label at the lowest. There was a higher statistical significance between each group except Spirit and Alphayue, Spirit and Larson Soloist, Larson Soloist and Prelude, Prelude and Helicore, and Helicore and Red Label.

Honorable Mention

Sriharsha Sambangi - Synergizing Scaffold Micro-Architectures and Mechanical Stimuli to Enhance Engineered Tissue Growth

Individual

Tissue engineering falls within the scope of Regenerative Medicine and its major goal is to develop living tissues to replace or repair damaged tissues and/or organs. Current medical practice nowadays in treating diverse diseases (such as in the cardiovascular or orthopedic areas) allows for patients with diseased or injured tissues/organs to be treated either via an organ transplant (either from a donor or from their own body as an autograft), or with a medical implant. But both approaches are riddled with problems such as shortages in organ donors, which is expected to rise as the population ages, implant failure or rejection, or simply the synthetical alternative is not ideal. As such, scientists have looked into the field of Regenerative Medicine and tissue engineering using techniques like, cell transplantation, material science, and bioengineering to create biological substitutes that can act exactly like the diseased or injured tissue. One such way to fabricate functional tissues or organs suitable for implantation is through 3D-bioprinting. 3D-bioprinting involves layer-by-layer deposition of living cells, biomaterials, and supporting structures called the tissue engineering scaffold to create three-dimensional tissues or organs. The aim of this paper is to evaluate the effects of different micro-architectures of 3D-printed scaffolds to tissue engineering, created by altering the angle of orientation of the grid of fibers composing the scaffolds. Typically, engineered tissues are subjected to mechanical stimulation during culture such that cells embedded receive appropriate stimulatory cues to trigger, promote and enhance appropriate development. The central hypothesis of this study is that scaffold microstructure can be employed synergistically with mechanical stimulation to provide an appropriate mechanical environment for engineered tissue development. Specifically, we have investigated the effect of two types of configurations (staggered vs. non-staggered fibers), at different fiber orientations (0-90 degrees, 30 60 and 45-45). These geometries are first created using 3D-CAD software and then employed in FEM simulations depicting their deformations as when subjected to mechanical stimulation during culture. As a result, we have observed that staggered scaffolds carry higher stresses when deformed (as they have effectively a smaller number of fibers supporting the mechanical loads). Different fiber orientations were also translated into the microarchitecture in completely different deformation modes, with the 0-90 alignment leading to tensile/compressive stresses, while the 45-45-degree alignment was conducive of shear and distortion. Further research can be done on the experimental validation of our simulation results with experiments with scaffolds in an uniaxial tester. The natural progression of this research is to print these scaffold micro-architectures, design an experimental program, and obtain experimental data that could be used to calibrate the finite element models.

Madeline Miller - Developing a Method for Aquaculture of a Local Polychaete Worm to Replace Imported Bloodworms

Chesapeake Bay Governor's School

Polychaete worms are a class of marine worms that are typically used for fishing bait, more commonly referred to as bait worms. Bloodworms, *Glycera dibranchiata*, are a very popular fishing bait that are being harvested by hand from the coast of Maine and are shipped to coastal southern states including the Chesapeake Bay region. Bloodworms are extremely expensive and require immense amounts of human labor, and they are also being depleted from their native habitats due to overharvesting. If another method of bait worm production can be developed, the risks of ecosystem depletion, increased cost, and increased labor can be tackled. This study tests methods to determine if these worms can be successfully aqua cultured using a simple in situ enclosure method. Observations were made at two different sites, Oyster Seed Holdings on Gwynn's Island and Urbanna Creek, to see if this method was successful. Research showed that this method is most likely not the best method of aquaculture for marine worms, due to high mortality, assumingly caused by predatory access. Continuing to develop the most successful method for bait worm aquaculture would allow the environment to have the pressures off of it for it to begin to restore itself from habitat disruption and invasive species effects. It would also be able to provide a source of income for new establishments or increasing income and benefits for already existing aquaculture facilities, such as oyster or fish aquaculture.

Andrew Morin -The Effect of Various Soundproofing Materials and Various Decibel Levels on the Number of Decibels that Pass Through the Materials
Clover Hill High School

The purpose of this experiment was to determine which materials (of the materials tested) were the best at reducing sound. Knowing which materials reduce sound the best allows for companies to design cheap, compact headphones that children can use to prevent hearing damage when attending loud sporting events/venues with their parents. The materials were set up against a speaker which output 3 distinct decibel levels (80, 90, 100). A decibel reader was set up on the opposite side of the material as the speaker to record the results after the sound had passed through the material. Each test was run until 30 trials were recorded for each material at each decibel level. The materials that reduced the sound best at 80 dB were the exercise mat with an average of 74.83 dB, felt at 74.79 dB on average, and foam with an average output of 75.01 dB. The best sound reducing materials at 90 dB were felt with an average of 84.75 dB, foam at 85.36 dB, and cardboard at an average of 85.50 dB. The sound reducing materials that performed the best at 100 dB were the exercise mat at 91.33 dB on average, felt which had a 92.29 dB average, and foam which averaged 92.18 dB. A Two-Way ANOVA test was conducted to test the statistical significance of the data. The data was found to be statistically significant because the resultant P-value was below the 0.05

level of significance. The experimental hypothesis of this experiment was that jute, a fiber-like material, will reduce high decibels of sound and low decibels of sound more effectively than the felt, rug, blanket, towel, cardboard, foam, and exercise mat with the towel reducing sound the least. This hypothesis was not supported by the data.

Kiran Pisolkar -The Effect of Sand Composition on the Amount of Heat Stored for Potential Use as a Sand Battery
Clover Hill High School

The purpose of this experiment was to determine which granularity of sand particles, with or without table salt, would capture and retain the most heat. Knowing what size sand particles or sand with salt combinations retain the most heat can provide a significant benefit to creating sand batteries as an alternate energy source. The hypothesis was that the mixture of fine sand and table salt would capture and retain the most heat. To measure the heat retention, three containers were each filled with fine grained sand, coarse grained sand, and a mixture of coarse and fine (mixed) grained sand. Three other containers were filled with fine grained sand with table salt, coarse grained sand with table salt, and mixed grained sand with table salt. Each container was placed in a 232°C heated oven for 1 hour to create sand batteries. The fine sand battery was placed in 5000 grams of water with an initial temperature of 22°C and stirred continuously while the temperature was constantly checked and recorded. Once the water temperature started to fall, the maximum temperature of the water was recorded. This process was repeated for the five other sand batteries and was repeated 15 times for each of the six sand batteries. The difference between the maximum temperature and initial temperature of 22°C was entered into the equation $5000g \cdot 4.18(J/(g^{\circ}C)) \cdot \Delta T = J$ to determine the amount of heat stored (J). The control battery (mixed sand battery) produced a mean heat of 235.5 kJ. The fine-grained sand produced a mean heat of 221.5 kJ. The coarse-grained sand produced a mean heat of 239.7 kJ. The fine-grained sand with table salt produced a mean heat of 207.6 kJ. The mixed grained sand with salt produced a mean heat of 228.6 kJ, and the coarse grained with table salt produced a heat of 222.9 kJ. Once the data was collected, a One-way ANOVA test was performed to determine if there was a statistically significant difference. The results of the ANOVA test suggested that there was a significant difference between the levels of independent variables because the P-value was less than the level of significance. The null hypothesis was rejected, and the data did not support the research hypothesis.

Sanay Shah -The Effect of Parameter Count on Aerial Trash Detection Accuracy
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if the parameter count of a neural network would impact the accuracy of that neural network in aerial trash detection. The hypothesis was that the model with the highest parameter count (PC) would return the greatest precision and recall values. Three different models were used in this experiment: one with a PC of 7.2, one with a PC of 21.2, and one with a PC of 46.5. After analyzing drone flight footage with plastic bags strewn across a local high school's football field, all three models returned precision and recall values, computer-generated values, which are indicators of a model's overall accuracy. These values were generated after training with individual frames from flight video. A correlational test determined significance, with a correlational value of .909 for the correlation between recall and PC, and a value of .655 for the relationship between precision value and PC. Correlational values of .909 and .655 both indicate a strong correlation to parameter count, supporting the original hypothesis that increasing parameter count would improve the accuracy of trash detection neural networks. The results suggested that increasing the parameter count in trash detection neural networks is conducive and correlated with higher overall model accuracy.

Sebastian Ploch -The Electromagnetic Shielding Capability of Different Materials
Central Virginia Governor's School for Science and Technology

The purpose of this research was to determine the best material for electromagnetic shielding out of aluminum, brass, carbon fiber, and copper. The experiment consisted of running an Electromagnetic Interference (EMI) source inside of boxes made out of 1.214 mm thick sheets of each material and observing how much of that signal passed through and reached a nearby transmission line. The EMI was measured from the transmission line using a Digilent Analog Discovery 2 waveform generator/analyzer. The data was analyzed through an ANOVA test of analysis, which yielded a p-value of .5. This value, being greater than the alpha value of .05, indicated that the results did not have a significant difference among groups. and did not support my research hypothesis stating that the more conductive materials would be more effective in blocking EMI. Overall, this experiment was conducted with few issues however, the results were inconsistent with several similar studies.

Linus Putnam -The Effects of Differing pH Water on Concrete's Compressive Strength
Central Virginia Governor's School for Science and Technology

This research study is about the effects of differing pH water solutions on concrete. The study was conducted to simulate acid rain on concrete to measure the degradation of

the compressive strength. The experiment was performed using acetic acid to lower the pH of the water and ¾ inch gravel combined with Portland cement to act as the samples concrete. The concrete was then soaked in the water with daily alterations to the solutions pH to bring it back 4 pH. The concrete samples were soaked in the solution/water for five days. The results concluded that the concrete in the solution and the concrete in the water were both stronger than the concrete that was left dry as control. The concrete in the solution and the concrete in the water did not have a significant difference between them. Using an alpha value of .05 brought a p-value of .0195 that showed that my results were in fact significant. This was found by using a one factor ANOVA test as well as a Tukey test to make sure there is a difference between groups. Lastly, the hypothesis that the water-soaked concrete would be the strongest, followed by the dry concrete and finally the acid-soaked concrete, was incorrect. The concrete samples soaked in the solution, or the water were stronger than the concrete that was dry. This suggests a deeper reason that may alter all kinds of submerged concrete.

EGR - Engineering – D

First Place

Kyler Williams - Effects of Supportive Insoles on Foot Pressure and Performance During Soccer Movements

Blacksburg High School

Over-the-counter supportive insoles are commonly used by athletes to address various biomechanical issues, including flat feet. However, supportive insoles may have adverse effects on soccer-based agility movement performance speed by being too bulky to allow the foot to function properly. This study aimed to test the effectiveness of an off-the-shelf athletic supportive insole (Superfeet (Superfeet Worldwide, Ferndale, Washington, USA)) and a low-profile supportive insole designed by the researcher (LPI) at supporting the medial-longitudinal-arch of the foot and their effects on performance speed during agility movements. A single participant completed a sprint and slalom using soccer cleats (control), soccer cleats with Superfeet, and soccer cleats with the LPI in a randomized order on two testing days. pedar® (novel electronics, Pittsburg, PA, USA) pressure sensors were placed underneath the participant's foot to measure foot pressure distribution, which can infer medial longitudinal arch support, and a stopwatch measured completion time. The averages and standard deviations of the pressure and completion time data were calculated for each footwear condition and then compared qualitatively. Superfeet generally had a slightly greater completion time than the control and tended to

increase pressure under the medial-midfoot region, indicating that Superfeet effectively supports the medial-longitudinal arch. The LPI had completion times similar to the control and appeared not to alter foot pressure, indicating the LPI does not support the medial-longitudinal-arch. However, since this study had only one participant, these results are highly preliminary. Rather, this study provided data on how to improve the LPI and served as a proof of concept for future research seeking to improve supportive insoles for athletes.

Second Place

Isabella Sisson -The Effect of Different Paint Colors on the Rate of Heating/Cooling of Water over Time

Clover Hill High School

This experiment was performed to determine whether the color of a pool affected the maintenance of the temperature of its water. Results could help increase energy conservation when it comes to heating and cooling swimming pools. Jars were painted white, red, yellow, and blue and placed under a heat lamp. Their temperatures in five-minute increments were then recorded, and the rates between increments were determined. It was hypothesized that red acrylic paint would cause the water to have a slower heating rate and a slower cooling rate than other colors, therefore maintaining its temperature the best. However, this hypothesis was not supported. Overall, yellow heated the fastest and white heated the slowest, while yellow cooled the fastest and white cooled the slowest. The data for this experiment was not significant, so the null hypothesis was not rejected.

Third Place

Kallen Wilt - The Effect of Brand of Tennis Shoes on Difference in Tread Depth Over Time After Simulation of Running

Clover Hill High School

The purpose of this experiment was to determine what brand of tennis shoe would lose the least amount of tread over time. This experiment would allow buyers to know what brand of tennis shoe would offer the most sustainability in terms of tread durability. Four levels of independent variables were tested in this experiment: Adidas, Under Armour, Asics and Saucony brand tennis shoes. For each of these brands of tennis shoes, the change in tread depth was tested at 10 locations: the heel, bottom, bottom left, bottom right, middle left, middle right, top left, top right, top and toe parts of each shoe. The hypothesis for this experiment was: If running were simulated on different brands of tennis shoes, then Adidas Shoes would lose the least amount of tread. The process of

this experiment went as follows: First, a stationary exercise bike was propped up off the ground and a mannequin foot was attached to the left pedal. Next, sandpaper was placed and secured to the ground under the left pedal. The left shoes of all 4 brands then had their tread depth measured and recorded at all 10 trial locations using a tire tread depth gauge. Then, the left Adidas brand shoe was put on the mannequin foot and the pedal was rotated 100 times, with the tread of the shoe scraping the sandpaper each rotation. After 100 rotations the shoe was taken off the mannequin foot and the tread depth was measured and recorded again at all ten trial locations. This process was repeated ten times for each brand of shoe. Finally, the amount of tread lost during each trial was calculated using the tread depth values that were recorded previously. The results of the experiment did not show a meaningful trend between the brand of tennis shoe and amount of tread lost, with the tread loss of each brand of tennis shoe varying widely between each trial. A two-way ANOVA test was conducted to decide if the results were statistically significant and determined that the results were not statistically significant. The research hypothesis was not supported, and the null hypothesis was not rejected.

Alec Stickle -The Effect of Stride Length on Piezoelectric Generation While Walking
Central Virginia Governor's School for Science and Technology

This study was designed to investigate the optimal stride length for maximum voltage generation through a piezoelectric element in the sole of a shoe. A simple circuit was made and inserted into the back heel of a tennis shoe. After that, a PVC pipe cage was constructed to consistently measure five specified stride lengths: 0.5 feet, 1 foot, 1.5 feet, 2 feet, and 2.5 feet. Using this cage, trials of 30-second time increments were recorded of the voltage spikes measured by a multimeter connected to the circuit with the maximum of each trial being recorded. The averages for the stride lengths tested were 46.46V for .5 foot, 45.59V for 1 foot, 57.57 for 1.5 feet, 41.46V for 2 feet, and 35.42 for 2.5 feet. A single-factor ANOVA statistical test was run on the data with an alpha value of .05, resulting in a p-value of 4.99×10^{-6} . This showed that there was a significant difference, a posthoc Tukey test revealed that the significant difference was between the 0.5' and 1.5', 0.5' and 2', 0.5' and 2.5', 1' and 1.5', 1' and 2.5', 1.5' and 2', 1.5' and 2.5' and between 2' and 2.5'. The research did not support the stated hypothesis that the longest stride length would produce the highest voltage output - instead, it suggested that a 1.5' stride length was optimal for voltage output. This research allows us to better understand how to apply piezoelectric elements in personal power generation devices.

Cullen Whitmore - Microscopic Analysis of Decay Potential of Dental Implants in Vinegar

Central Virginia Governor's School for Science and Technology

This study was designed to test the significance of the reactivity between cheaper materials often used for dental implants and common culinary components. The chosen implant materials were carbon PEEK and 316L stainless steel, while the culinary elements were distilled water and white vinegar. 60 wells were filled with 15mL of liquid each, half with water and half with vinegar. Then, four groups of fifteen were formed, with each group containing samples of one of the material types submerged in one of the liquids. No groups were identical in their pairing. For six weeks, a Stemi 305 Zeiss Stereoscope was employed to periodically visually scan the samples for ongoing deformation. Afterward, the samples were measured. The dimensions remained similar, so only the masses, which did vary, were compared in a two-factor ANOVA test. A Tukey post-hoc test revealed that the only significant difference, based on an alpha of .05, was between the masses of two materials. This difference was expected, as the two materials had dissimilar densities, so there was no significant difference between the groups' responses to exposure, and my hypothesis that the steel/vinegar pairing would change most was not supported. In grams, the plastic samples had masses around 0.915, and the metal around 5.023. The P-value was .787 between the samples themselves, and .854 for their relationships. Based on these values, it can be concluded that, within similar time frames, PEEK and stainless-steel show similar integrity in this particular sort of dental environment.

Zaara Uddin, Ninette Amaya Rocha, Yassen Ben Chouikha - CO-Clean: Filtering Emissions for a Better Future

Governor's School @ Innovation Park

As greenhouse gas levels in Earth's atmosphere increase exponentially, the need to lower daily carbon emissions grow each day. Currently, the highest contributor to greenhouse gas emissions in the US is daily transportation. This project aims to reduce carbon emissions from cars by creating an adjustable exhaust pipe attachment which will use CO₂ and H₂O Co-Electrolysis to convert CO₂ to O₂. The prototype was created using PVC Pipes, plastic for the casing, small plastic containers, an H₂O electrolyzer, Arduino, SCD 40 CO₂ Sensor, general hardware/tools, and personal protective equipment. The Arduino IDE software was used to code the sensors, and the prototype was built with little need for power tools. The electrolyzer (as the main component of the prototype that converts the CO₂ to O₂) was assessed separately since fully embedding the electrolyzer into the body of the prototype was unfeasible during the period of this project. To test the electrolyzer, two containers were filled with water with silicone tubes

allowing water to flow through the electrolyzer placed between the containers, increasing concentrations of CO₂ were on the input side of the electrolyzer, and the SCD 40 CO₂ sensor was used to determine the CO₂ concentration in PPM on both sides of the electrolyzer. The difference in the CO₂ concentration is the concentration of O₂ produced by the electrolyzer. The results of experimentation showed that as the concentration of CO₂ in PPM increased, the concentration of O₂ produced also increased. This means that the electrolyzer was effective in converting CO₂ to O₂, proving that the electrolyzer (and therefore, our prototype) was successful in achieving its goal. The societal impact of the prototype will be to lower the carbon footprint of vehicles in daily life.

Tess Vithoulkas -The Effect of Different Solar Still Condenser Shapes on the Rate of Distillation

John Randolph Tucker High School

Living things need water to survive; however, many people in different places of the world have difficulty finding clean water. Most of the Earth's water is found in its oceans, but the salty solution cannot be used for drinking. Humans can purify ocean water for drinking through distillation using a solar still. The water in the still is evaporated by the sun's energy, which causes it to rise to a condenser plate and roll into a collection container as clean, drinkable water. In a previous experiment, this experimenter discovered that glass was the most effective condenser material, when compared to polycarbonate and acrylic. The purpose of this experiment was to determine which condenser shape produced the most water in a twelve-hour period. Based on research showing that a hemispherical condenser had better thermal efficiency, the hypothesis was if a hemispherical condenser is used, then the highest rate of distillation will occur. Three different condenser shapes were selected as the independent variable: double pane, hemispherical, and pyramidal. A bowl filled with 89.5 g of water served as the basin of the still. A lamp was used to simulate the sun. Ten trials for each condenser were conducted. The results from the experiment indicated that the hemispherical still had the highest rate of distillation with a mean of 0.054 g/cm², while the double pane still had a rate of 0.027 g/cm², and the pyramidal still had the lowest distillation rate of 0.021 g/cm². A one-way ANOVA test was performed on the data to test whether the means of the data were statistically different. The f-value was 138.157, the f-critical value was 3.354, and the p-value was 6.575E-15, indicating that the means were different. Following the ANOVA test, a Tukey's HSD test confirmed that each shape was statistically different from the others since the p-value was less than 0.05 for all three comparisons. Thus, the results supported the hypothesis that a hemispherical still would have the highest rate of distillation.

Aditya Sunilkumar -The Effect of Sidepod Type on Vehicle Performance
Mills E Godwin High School

The present study focuses on a CFD analysis of various side pods on vehicle performance. The study aims to contribute to the aerodynamic studies of Formula One by testing the negative and positive impacts side pods have on F1 Cars. Drivers are racing almost every weekend with g-forces equivalent to fighter pilots every turn making the sport fantastic and entertaining, thus why research must be credible and why this experiment was tested. The hypothesis for this research experiment was that if the Shark-Fin side pod is used on the car, then it will have the greatest vehicle performance, and this was unfortunately unsupported. The experiment had no control since there was no base type of side pod. To complete the experiment, a CFD and 3D model of the Formula One 2022 Concept chassis were acquired. Each side pod type was molded onto the 3D model and was tested on the CFD 25 times each. Analysis was performed for three dependent variables: lift, aerodynamic resistance, and downforce. Results show that the T-wing side pod had the highest mean amount of downforce, and the T-wing side pod had the best performance as it was amazing in all categories. The inferential statistics tests prove that the data was indeed significant at a level of significance of 0.01. The experiment's results came out as they are now because of how the CFD simulations were performed and the aerodynamic tools each side pod uses.

Varun Yeri -The Effect of Various Dielectric Composites on Observed Capacitance in a Capacitor
Mills E Godwin High School

Capacitors play a crucial role in modern electronics, contributing to diverse applications. However, their use also raises environmental concerns due to e-waste production. This study aims to address this issue by investigating the efficacy of biodegradable dielectric composites. It was hypothesized that aluminum oxide will exhibit higher capacitance and dielectric constant than biodegradable composites, but that cellulose would exhibit the highest capacitance and dielectric constant out of the biodegradables. The chosen biodegradable dielectrics—agarose, cellulose, and amylose—were assessed for their dielectric constants in a capacitor. Copper parallel plate capacitors with different dielectrics were constructed by creating dielectric pastes and evaporating the moisture content. Emphasizing safety and precision using insulating gloves, each capacitor was tested using a digital LCR multimeter to measure capacitance 25 times. Results indicated that while aluminum oxide consistently

exhibited the highest dielectric constant (7.989), amylose unexpectedly surpassed other biodegradable composites (6.052 compared to 5.042 for agarose and 3.473 for cellulose). Statistical analysis with a t-test performed on the data confirmed its significance, as every calculated t value was greater than the critical t of 3.505; this implied a chance of error less than 0.01%. Aluminum oxide was found to have a lower dielectric constant than other studies, likely due to a difference in crystalline structure. Amylose likely had the highest capacitance of the biodegradables due to its low likelihood of dissociation into ions which conduct electricity. Further research should be conducted, measuring with more precision, in addition to charging time.

Anna Yi - Comparing the Changes in Temperature of Sustainable Insulation Materials
Central Virginia Governor's School for Science and Technology

This study aimed to determine which type of sustainable insulation would work the best as an everyday insulator. In this experiment, wool, recycled denim, and straw were tested in a glass tank under a heat lamp to determine which material had the smallest change in average temperature. Foam insulation boards were used on the outsides of the tanks and the insulation samples were cut to size and stuck between two perforated metal sheets to contain them in the middle of the tank. The heat lamp was set on one side and Vernier Heat Probes (one on each side) were set to administer the heat transfer. In total 30 trials were done, with 10 trials per sample and 30 minutes per trial. This experiment used a Single-factor ANOVA test and a post hoc Tukey Test to analyze further the data collected. The alpha value used was .05 and the pvalue recorded from the data was .0057, indicating a significant statistical difference between groups and thus, the null hypothesis was rejected. The original hypothesis was not supported by the data, which stated that wool would work the best because straw had the greatest results after analyzing the data from it having the smallest temperature change. There was a higher statistical significance between straw and recycled denim and lower between straw and wool, but none between recycled denim and wool. In conclusion, the results suggested that straw would make a good alternative for insulation.

ENV - Environmental and Earth Science - A

First Place

Marianna Anderson -The Effect of Ocean Acidification on the Photosynthetic Efficiency of *Dictyota dichotoma* and *Halimeda opuntia*
Collegiate

Halimeda are a type of calcifying algae that use calcium carbonate in their thalli. Ocean acidification has been shown to have varying effects on Halimeda, but it has generally been shown to have negative effects on Halimeda's photosynthetic efficiency (Schermer et al., 2016). *Dictyota dichotoma* is a noncalcifying algae that commonly grows on or near Halimeda. *Dictyota dichotoma* generally experiences no negative effects under ocean acidification (Asnaghi et al, 2013). There have been limited studies about the effects of ocean acidification on the photosynthetic efficiency of these two algae where ocean acidification is the sole factor. This research examines the effect of ocean acidification on the photosynthetic efficiency of Halimeda and *Dictyota dichotoma*. Three 3-gallon tanks and three 1200 mL beakers were acquired. One Halimeda plant, purchased from a local pet supply store, was placed in each tank along with 330 mL of salt-water. One vial of *D. dichotoma*, purchased from a biological supply company, was placed in each beaker along with 330 mL of enriched seawater medium, purchased from a biological supply company. The algae were grown for 3 weeks. Then equal masses of each alga was dried in a drying oven for 2 hours. The algae were then ground up and each algae sample was added to 3 mL of acetone and .2 mL of CaCO_3 in a test tube. These solutions were then frozen for 2 weeks. After two weeks, the solutions were removed from the freezer, 7 mL of acetone was added to each solution, and the absorbance of each solution was measured using a spectrophotometer. These absorbance values were then plugged into a standard equation and the value of the chlorophyll A concentration was determined. A t-test determined that there was a significant difference in the concentrations of chlorophyll a between Halimeda and *D. dichotoma*. A one-way analysis of variance determined that there was a significant difference in the concentrations of chlorophyll a between the 3 pH levels for the two species of algae. This data corroborates the research that Halimeda is negatively affected by ocean acidification but contradicts the research that *D. dichotoma* is neutrally or positively affected by ocean acidification. Overall, this research emphasizes the importance of stopping ocean acidification in order to prevent negative effects on marine algae.

Second Place

Emma Ackleson -The Effect of *Pseudomonas fluorescens* and *Bacillus cereus* on the Degradation of Microplastics.
Washington Liberty High School

This experiment evaluated and compared the biodegrading efficiency of two bacterial species, *Pseudomonas fluorescens* and *Bacillus cereus*, on polystyrene microplastics. It was hypothesized that if *Pseudomonas fluorescens* and *Bacillus cereus* bacteria were placed in sterile nutrient broth solutions and combined with polystyrene microplastics, the *P. fluorescens* will break down and feed on the polystyrene more effectively than the *B. cereus*. This is because *P. fluorescens* has a faster metabolism with a primary diet of carbon, the main component of polystyrene, and *B. cereus* has a relatively decreased capacity for carbohydrate metabolism compared to *P. fluorescens*. Both species of bacteria were cultured with 0.05 g of microplastics in separate nutrient broth tubes and incubated at 37°C. After 35 days, the remaining microplastics were filtered from the nutrient broth, treated with a bleach solution, and washed with water to remove any residual bacteria. The remaining polystyrene was then massed, and the data was analyzed. Results showed that both bacterial species were able to degrade microplastics, but *P. fluorescens* had a larger margin of degradation: *P. fluorescens* had a mean mass of 0.017 g, and *B. cereus* had a mean mass of 0.029 g. Results were then compiled in a data table and graph. An ANOVA test was conducted which yielded a p-value of 7.62×10^{-10} . The statistical tests indicate that the research hypothesis was supported, and the null hypothesis was rejected. Results from this experiment could be used as an alternative approach to reducing microplastics from the environment.

Third Place

Alexandria Swenson - Mean Frequencies of Microplastics in Commercially Processed Equine Feeds

Southwest Virginia Governor's School

Ingestion of microplastics (MPs) is becoming common in animals due to the contamination of food and water supplies. Manure samples were collected from three different equines. Equine One (E1) received no commercially processed feed and Equine Two (E2) received Purina Equine Senior Horse Feed. Equine Three (E3) received ProElite Grass Advantage Diet Balancer. Each of the equines were sought out for the experiment and had been ingesting the desired feed for a considerable time. Caretakers of the equines were responsible for the care and feeding of the equines. Each 200 mL sample was divided into five randomized 20 mL subsamples and analyzed under a microscope. In test group one, one MP was found in E1's sample, three MPs in E2's sample, and zero MPs in E3's sample. In test group two, three MPs were found in E1's sample, one MP in E2's sample, and four MPs in E3's sample. After performing an ANOVA test on group one, a p-value of 0.2841 suggested that there was not a significant difference in the MP frequencies between the two feeds. With a standard error mean of 0.4 counts for E1, 0.2 counts for E2, and 0.3 counts for E3. A

similar result was found after performing the ANOVA test on group two. A p-value of 0.7230 was given, as well as a standard error of 0.4 counts for E1, 0.2 counts for E2, and 0.8 counts for E3. There was not enough evidence to reject the null hypothesis, which stated that there was no difference in MP frequencies between Purina Equine Senior Horse Feed and ProElite Grass Advantage Diet Balancer. This study aimed to gain new data on the frequencies of MPs in commercially processed equine feeds, as a way of testing the safety of our animals and pets in our ever-changing world.

Honorable Mention

Joshua Althaus -The Effect of Pyrethrin-Based Pesticide on Pill Bug Activity
Mills E Godwin High School

The purpose of this experiment was to observe whether pill bugs demonstrated an aversion towards pyrethrin-based pesticides. If pyrethrin-based pesticides are shown to hinder pill bug activity, farmers and gardeners should know and take this into account when selecting proper repellants, as pill bugs provide important services such as nutrient cycling and decomposition. 30 pill bugs were placed into a box divided up into four quadrants of equal size, with each quadrant containing soil treated with varying amounts of Bonide Pyrethrin Garden Insect Spray. One quadrant was administered no pesticide and acted as the control. A hypothesis was formed that predicted that the quadrant with no pesticide content would house the most pill bugs by the end of the experiment. The results revealed that, over time, pill bugs began to congregate towards the control and quadrant 1, the two quadrants containing the least amount of pesticide content. Following several Chi-square tests, it was discovered that the data taken at hour 1 and hour 2 are significant, but the data taken at hour 3 is not significant. It is believed the pyrethrin-based pesticide harmed the pill bugs, leading to them attempting to move away from the most potent sources of the chemical as time went on.

Honorable Mention

Khadeejah Alsheikh, Kayla Minter, Willow Weeks - Putative Toxins and their Effect on Copepods in the Chesapeake Bay
Governor's School @ Innovation Park

This study assesses how Organophosphorus pesticide (Malathion) and acetaminophen (paracetamol) affect *Cyclops copepods* in the Chesapeake Bay. It aims to discover the behavioral and survival impacts of these toxins on copepod communities. Despite initial perceived benefits, research reveals long-term detriments: heightened vulnerability to predation and decreased survival rates in *Cyclops copepods* post-toxin

exposure. These consequences influence predator-prey dynamics and overall Chesapeake Bay health, pivotal for local economy, recreation, and community well-being. The experiment involved exposing *Cyclops copepods* to various abundant toxins (Malathion, Acetaminophen) in controlled environments mimicking their habitat of the Chesapeake Bay. Observations assessed acute and chronic effects on copepod behavior survival rates. To ensure uniform distribution, individual counting methods were employed. This research is vital for understanding toxin impacts on *Cyclops copepods*, integral to ecosystem preservation and human welfare in the Chesapeake Bay. It aims to offer solutions to environmental challenges, supporting the bay's sustainability while addressing concerns of environmental justice and ecological stability. Overall, these findings suggest a significant vulnerability of *Cyclops copepods* to anthropogenic toxins present in Chesapeake Bay. These findings affirm the hypothesis of Malathion causing the most adverse side effects on *Cyclops Copepods*, significantly decreasing survival rates. The data indicates that increased concentrations of Malathion and acetaminophen induce adverse effects on copepod populations, leading to decreased survival rates but with Malathion having a 3% survival rate compared to the 17% survival rate of Acetaminophen. Malathion and Acetaminophen both had a p value < 0.05 , in comparison to the control, which shows significant statistical difference in the toxins effect on the copepods.

Amna Abdelbagi -The Effect of Different Levels of Salt Concentration on Plant Growth
Arlington Career Center

Road salt can be defined as heavy amounts of salt that are distributed onto roads that reduce the freezing point of ice when it snows. While this clears up the road quicker for safer driving, it can worsen the impact on the plants that live beside the road. The purpose of this experiment was to test out different salt concentrations that range from low to high to determine the maximum amount of salt a salt-tolerant plant needs to tolerate and grow. It was hypothesized that if the plants are watered with different salt solutions, then the 3.5% salt solution will grow the highest because less salt increases growth. The independent variable is the different levels of salt concentration. The dependent variable is the plant height, measured in centimeters. The experimental variables were 0%, 3.5%, 5%, and 8% salt concentrations. The experiment consisted of four bins that include ten individual trays in each bin. Each of the 4 bins was labeled as the experimental variables that had ten trials. The salt concentrations consist of the respective amount of salt for each experiment group mixed with 44 mL of purified water. Out of all four experimental groups, the results revealed that the 0% salt concentration was the most successful at growing the most height and that the 3.5% salt concentration was second best. The 5% and 8% salt concentrations grew the least, making them the experimental group that grew the least. Although both the 3.5%

and 5% salt concentration groups grew, they did not grow as much as the 0% salt concentration group because the beach sunflower plant could not handle the amount of salt it had in the concentration. This also occurred for the 8% salt concentration, but the plants that received high salt concentrations and did not grow demonstrated how salt is a big factor in plant growth.

Clara Amundson -The Effect of Smoke from Various Burnt Materials on the Height Difference of Cat Grass

Individual

This experiment was designed to test how significantly smoke sourced from various burnt materials could hinder the growth of cat grass. Particles and chemicals carried in smoke can be detrimental to a plant's health by damaging stomata and chlorophyll or by blocking sunlight. The extent of the damage inflicted on the plant varies by the source of the smoke. To test this, cat grass was grown for a week, divided into 5 equal sections, and placed into large glass jars. Each variable — oak wood, wet (silver maple) wood, plastic packaging labels, and magazine papers — was ignited and placed in a small glass jar, which was then placed inside the larger jar containing the cat grass. The large jar was screwed shut, and after a 30-minute exposure to the smoke, the cat grass was repotted and grown for an additional week. The height of the tallest strand of grass was measured and recorded before smoke exposure and again a week later. This process was repeated for four trials. It was hypothesized that smoke from magazine papers would have the greatest negative effect on growth, with smoke from natural materials having the least negative effect. For the most part, the results supported the hypothesis. Across all four trials, the average number of centimeters grown after smoke exposure from each variable is as follows: no smoke (control), 5.375; oak wood, 4.55; wet wood, 6.1; plastic packaging labels, 4.025; and magazine papers, 4.075. Research indicates that these results occurred because smoke from plastic contains more toxic chemicals than smoke from a natural material. These chemicals have the capability of affecting natural processes in the plant. Wet wood, however, had the minimum effect on the grass' growth. Based on research, a series of chemical reactions from burning wet wood can change the carbon monoxide produced by the smoke into products beneficial for a plant's growth.

Sajeela Ahmad -The Effect of Toxic and Green Detergent on Red Worms (*Eisenia fetida*)

Individual

The objective of this research is to find the effect of both toxic and "green" detergents on red worms (*Eisenia fetida*) and see if there is any notable difference in the mortality of worms when exposed to these different detergents. The hypothesis is "If red worms are exposed to a toxic detergent solution, 100% of them will die on average (of all the trials); and if a "green" detergent solution is used, then 10% will die on average." The independent variable is the detergent type, either toxic (common) detergent or green detergent. The dependent variable is the number of worms that survive when exposed for 5 days. The planned procedure was to buy red worms from Carolina Biological. The worms would be kept inside in a cool room, at temperatures suited to their needs. They were placed inside plastic cups with tight lids with 5 holes for air. The lids prevented them from escaping. The bedding was 25 grams of peat moss and 35 grams of tap water. There were 5 grams of detergent in the toxic and green detergent trials. The detergent was mixed with water before being mixed with peat moss. The toxic detergent was a common laundry detergent (toxic and common are the same, common meaning commonly used by the public) that stated it had no phosphates for human safety and the green detergent states it was 75% plant based. The worms stayed in these cups for 5 days before they were taken out and the number of living worms was tallied. The data was written down on a sheet of paper. It was hypothesized that 100% of the worms in the cups with toxic detergent would die and 10% of the worms in the cups with green detergent would die, because the toxic detergent was not made with environmental safety in mind. The green detergent was made to be environmentally friendly. Therefore, it was expected that the green detergent would be much safer for the worms to be exposed to than the toxic detergent. The key result of this experiment is that all worms exposed to both the toxic detergent and the green detergent died. This is also supported by the control group, in which 88% of the worms lived, so the worms did not die due to less-than-ideal living conditions, but indeed died due to the detergent. The hypothesis was half supported because it predicts that 100% of the toxic detergent worms will die, which was supported by the results. However, the results did not support that 10% of green detergent worms will die, and instead they show that 100% of the worms exposed to green detergent died as well.

Anshika Yadav -The Effect of Polluted Water Runoff on *Daphnia magna*
Mills E Godwin High School

This study investigates the effects of water pollution on *Daphnia magna* and its significance in managing water resources. The findings can aid policymakers, scientists, and organizations in preserving aquatic ecosystems and promoting a healthier environment, the goal is to create a sustainable and healthier world by mitigating pollution's impact on aquatic life. The hypothesis in this experiment was that if a portion of water runoff from a local farm is used, then the number of fatalities of the

Daphnia magna would increase. The experiment involves One cup of polluted water runoff from various sources will be collected and added to four labeled containers, each containing 25 Daphnia magna. Furthermore, a jar of non-chlorinated water will be employed as a control to observe the ideal environment for Daphnia magna. The Daphnia magna will be observed over the next 2-3 weeks for changes in fatalities. The study discovered that water runoff from parking lots led to higher fatality rates in Daphnia magna and the original hypothesis was rejected, and the null hypothesis was not rejected due to some imprecision in the data. Overall, the results indicate that water runoff from parking lots has a significant impact on the mortality rate of Daphnia magna. The study examined the impact of polluted water runoffs on Daphnia magna mortality rates, revealing high death rates from parking lot water. The statistical test was inconclusive, indicating potential inaccuracies. Future research should be conducted on a larger scale to understand the damage caused by water runoff.

Swati Aggarwal - Evaluating Homemade and Industrial Rust Removers on Steel Metal
Southwest Virginia Governor's School

This study compares how effective homemade and industrial methods are at removing rust. Having rust on metals is very dangerous and being able to remove it is very important. If the rust remains, then the metal parts' overall structure will deteriorate and have a shorter lifespan. These safety hazards can negatively affect industries and the environment. Although it is important to remove the rust, the whole process shouldn't be as dangerous as leaving the rust there. Many industrial methods of removing rust are extremely dangerous and require extreme care and maintenance to use. Homemade methods are safer to use and are more beneficial to the environment. The experiment was done by first gathering the steel metal samples and rusting them. After the bars were rusted, all the homemade and industrial methods were tested and compared on the bars to see how much rust was removed. There are two types of methods being evaluated: homemade methods and industrial methods. The homemade methods are lemon juice, baking soda, and vinegar. The industrial methods are a wire brush, oxalic acid, and phosphorus acid. The overall amount of rust that was removed was 0.1399g, 0.1024g, 0.1791g, 0.1630g, 0.0952, and 0.1424g respectively. An ANOVA test revealed that there is a significant difference as the p-value is less than 0.0001 and a follow-up Tukey test was done to see the differences between all the rust removal methods. The homemade methods are slightly better than industrial methods, and more testing and experimenting need to be done to see whether this is truly the case. The research that was done was about other people's methods of removing rust and how they did it.

ENV - Environmental and Earth Science -B

First Place

Taylor Douglass - Alternative Natural Air Filter Media Impact on Air Quality
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine the most efficient eco-friendly air filter alternative for indoor use. A 4ft by 1ft-by-1ft air filtration chamber was constructed to measure the particulate matter that passes through various filters in a controlled environment. Particulate matter was produced by igniting two index cards to produce smoke. The filtration efficiency of three different filter media was then observed: moss, cotton, and coffee filters. The data was separated into three, one-way ANOVA tests for analysis (PM1, PM2.5, and PM10). The chosen alpha value of .05 exceeded all generated p-values of .037, .024, and .014, respectively, thereby rejecting the null. A Tukey test was then performed and generated minimum difference values of 90.664, 176.605, and 252.875 (PM1, PM2.5, and PM10). The values that exceeded each of their respective minimum difference values were 100.125, 200.5, and 252.875 (PM1, PM2.5, and PM10). Each Tukey test produced similar results in that moss and coffee filters demonstrated significant differences. This data supports the research hypothesis that moss would perform the best when compared to cotton and coffee filters as alternative air filters. There have been climbing rates of wildfires and other events caused by climate change, thereby causing a rapid increase in poor air quality. The results of this study contribute to slowing the increasing health and environmental effects of climate change and non-biodegradable air filters.

Second Place

Emily Paul - Creating a Close Chamber System to Measure Carbon Dioxide Efflux from Far North Environments
Southwest Virginia Governor's School

Carbon dioxide (CO₂) efflux is the measure of gas diffusion through material as a result of microbial decomposer activity and is a useful measure for forming carbon (C) budgets to create effective environmental policy. Measuring CO₂ efflux in Arctic and subarctic environments may be an indication of how climate changes affect other environments globally. However, several sources of error have been identified in measuring CO₂ efflux such as pressure, deployment time, and calculation. This study investigates the effect of internal headspace fans in a closed chamber system (CCS) on the measurement of CO₂ flux rate. To accomplish this, a chamber was constructed to

serve as a simulation of CO₂ mixing in soil and allowed CO₂ to diffuse through a perforated lid into the CCS. Underestimation of true flux values was observed in all conditions except in the No Fans/No Ice group. It was found that there was a statistically significant difference (p-values ranging between <0.0001 and 0.0009) between tests which used ice and tests that did not use ice, which was expected. No significant difference was found between trials which had operating headspace fans and those that did not (p-values of 0.6152 and 0.9206). It was predicted that the internal headspace fans would prevent underestimation of flux, however this data suggests that the underestimation of flux could be caused by a factor other than improper air mixing and may suggest that temperature has a quantifiable effect on flux measurements.

Third Place

Annie Eubanks -The Effect of Superabsorbent Polymer Composition on Water Retention of Hydrogels

Mills E Godwin High School

This experiment aimed to examine the effects of superabsorbent polymer composition on the water retention properties of hydrogels. The initial objective was to compare to efficacies of synthetic, natural, and semi-synthetic hydrogels to determine the most absorbent and retentive composition for ameliorating agricultural water consumption, which has applications in mitigating water scarcity and improving crop yield. Retention was measured through water holding capacity (WHC) via centrifugation of each gel sample at 3400 rotations per minute (rpm) for 20 minutes, as well as through percent change in mass of the gels over a 48-hour period. It was hypothesized that sodium polyacrylate-based gels would exhibit the highest water holding capacity after centrifugation and the lowest percent decrease in mass after 48-hours; the data was later determined to support the hypothesis that sodium polyacrylate-based gels would exhibit the highest WHC, but did not support the hypothesis that they would experience the lowest decrease in mass as the semi-synthetic gels had the lowest negative percent change over the given period. A t-test determined the results to be statistically significant overall at a 0.05 level. The high WHC capacity of the sodium polyacrylate-based gels was attributed to the chemical's abundance of sodium cations that optimize the uptake and retention of exogenous water molecules within a loose polymeric structure, while the low percent decrease in mass of the semi-synthetic gels was attributed to the polymer's high cross linkage density, thus affording it greater gel strength and increased ability to retain water via hydrogen bonding at cross-linkages.

Honorable Mention

Bridget Falgui -The Effect of Heavy Metal Concentration (Lead (II) Nitrate) on *Daphnia magna* Heart Rate

Mills E Godwin High School

With the pressing issues of heavy metal contamination in aquatic ecosystems, this study explores how lead nitrate affects the heart rate of *Daphnia magna*. This investigation examines the environmental and health risks associated with heavy metal pollution. Lead (II) nitrate is a common heavy metal found in paints, agricultural runoff, and mainly industrial emissions leading to eventual bioaccumulation in higher trophic levels. *Daphnia* is considered an indicator species meaning its presence and behavior can provide meaningful information on the health of an ecosystem. This experiment will highlight the effects of heavy metals on aquatic ecosystems and bring light to the detrimental effect of pollutants on ecosystems. It is hypothesized that a higher concentration of lead will lead to a lower average heart rate of *Daphnia*. Spring water, which is used as the control in the experiment since it acts as normal conditions will have the highest average heart rate as the baseline. For each IV level 25 *Daphnia* were placed on microscope slides and exposed to 0.1 M and 0.01 M lead concentrations, and spring water. After acclimation, *Daphnia* heart rates were measured using a microscope, a timer, and data sheets. Results disclosed that 0.1 M solution had the lowest average heart rate, and the spring water had the highest average rate meaning the research hypotheses were supported. A t-test was performed revealing all comparisons are statistically significant at a 0.01 level. The experimental results emphasize the need for environmental protection for these pollutants to save aquatic ecosystems from harm.

Honorable Mention

Abigail Frias -The Effect of Types of Wood, Soaked in Water for Prolonged Periods of Time, on the Difference Between the Initial Circumference and Final Circumference and the Difference Between the Initial Weight and the Final Weight

Clover Hill High School

The question that was addressed in the experiment was which wood type would absorb the most amount of water over a prolonged period of time. The purpose of the experiment was to determine the amount of water that a piece of wood could absorb. The hypothesis was that softwoods would have the greatest change in circumference and weight, over time, after being soaked in water, and the hardwoods would have the least change in circumference and weight after being soaked for a prolonged period of time. Four different wood types were used, 2 hardwoods and 2 softwoods. The woods included cedar, poplar, pine, and oak wood. There were 30 pieces of each that were placed in containers filled with water. The wood was then left in those containers and the growth of the wood was tracked weekly by circumference and mass. The data regarding the circumference and mass of the wood pieces that were used were summarized in tables and displayed in graphs. From the experiment and the ANOVA

tests that were conducted, it was concluded that the softwoods absorbed more water than the hardwoods. The highest mean weight was oak wood's 41.77 g, while the lowest weight's mean was cedar wood's 26.07 g. The highest circumference was oak wood's 14.05 cm, and the lowest circumference mean was cedar wood's 4.58 cm. The null hypothesis was rejected, but the research hypothesis was supported.

Nathalie Biddlecomb -The Effect of Varying Baits Used in Crab Pots on the Quality of Crabs Caught

Chesapeake Bay Governor's School

Blue crabs, or *Callinectes sapidus*, play a key role in the Chesapeake Bay today, serving as both a keystone species and an indicator of the bay's health. Furthermore, crabbing in the Chesapeake Bay is a crucial part of many people's lives, along with the economy because so many blue crabs are sold commercially in the bay area. This study hopes to find the most sustainable bait which watermen can use to get the best quality catch. It considers the effect of different baits on the abundance and quality of crabs caught, measuring the mass, and lateral spine length of each crab. Ten crab pots were set out, three of each with different bait (menhaden, chicken, squid), and one as a control with no bait. The crab pots were set in a line in Cockrell's Creek for a five-day period, checking and measuring abundance, mass, and size of each crab caught once daily. This was repeated for two trials: once in June and once in August. The results found that the abundance of crabs was significantly increased when being caught with bunker versus chicken or squid. However, bait type had no significant impact on....(your other three hyp). Therefore, to increase catch rate, one should use menhaden as bait, however, if one were to use chicken or squid the quality of catch would not be affected. This could give watermen a few alternative baits to use, which would help the Chesapeake Bay in the long run, as it prevents overfishing and population decline of both menhaden and blue crabs.

Colin Badcock - The Effect of Varying Amounts of Hydrilla on its Ability to Filter Polluted Water, based on pH, Dissolved Oxygen Levels, and Nitrogen and Phosphorus levels, Over Time

Clover Hill High School

Hydrilla, an invasive aquatic plant species, may be able to filter water over time. The hypothesis of this experiment was: the more Hydrilla that would be added to a body of water, the cleaner the body of water would become and would result in higher Dissolved Oxygen levels, higher pH levels, and a decrease in TDS levels, over time. During this experiment, Hydrilla was taken out of a reservoir, placed in containers filled with water

and sediment. Over the course of two months in the summer, Hydrilla was tested for pH, dissolved oxygen, TDS, and Nitrogen and Phosphorus levels. Within the testing the pH had changed overtime and so did TDS slightly. Nitrogen and Phosphorus levels had virtually no change at all. The null hypothesis for pH was rejected, while for dissolved oxygen and TDS the null hypothesis was not rejected. The research hypothesis was not supported due to these results.

Xavier Gitre -The Impact of Environmental Methylmercury Exposure on the Feeding Rates of Invertivorous Passerines
Blacksburg High School

The impact of environmental exposure to methylmercury (henceforth MeHg), a potent neurotoxin, on the feeding rates of resident invertebrate-eating songbirds in winter was examined along a stretch of the South River, a waterway contaminated with mercury, north of Waynesboro, Virginia. Research into the neurobiological effects of MeHg exposure in birds has established a variety of potential impediments to avian foraging, such as behavioral alterations that result in the avoidance of high-energy behaviors and impeded coordination. It was hypothesized that invertivorous passerines with high environmental MeHg exposure would exhibit decreased feeding rates when compared to those with little or no exposure. This was tested by the measurement of feeding rates of resident species with the highest mean blood MeHg concentrations at contaminated sites. A statistically significant difference was observed between feeding rates of target species at contaminated and reference sites, a difference that was accentuated in Carolina Wrens, the species with the highest known blood MeHg concentrations at the study sites, and absent in Carolina Chickadees, a species with lower blood MeHg concentrations. However, it should be noted that the sample sizes were small. More data must be collected through a variety of methods before definitively establishing a correlation between MeHg exposure and decreased feeding rates and efficiency.

Mishaal Haq -The Effect of Activated Carbon on the Quantity of Chlorine in Water
Mills E Godwin High School

The intent of assessing activated carbon on chlorine was to establish how activated carbon affected the contaminants in water, and whether it was a good water purification method. Water was important to everyday life and its quality influenced the health of the environment and life around it. Additionally, water comprises 60% of the body. Purification of water was a task that was always important to the environment and life that relied on it. The water was treated with 600 mg of activated carbon, 300 mg, 150 mg, and no activated carbon at all, which was the control after the starting chlorine

amount was solidified. They were measured after 600 seconds in ppm. The initial and final amount of chlorine was acknowledged to show the change from the carbon. It was hypothesized that if there was more activated carbon in the water, then there would be less chlorine present. The results revealed that more activated carbon resulted in the purification of chlorine. The water with 300 mg of activated carbon almost entirely cleaned the water of chlorine. A t-test was calculated and determined that the data was significant, so the hypothesis was supported. The results were most likely because activated carbon had a texture of macropores, which increased surface area and allowed absorption of chemicals in water. Other studies suggested that activated carbon purified water to the point where there weren't contaminants left at all. Further studies would include measuring the chlorine using a different tool, like wavelength or UV absorbance.

Zoe Camp – Does the Presence of Macroalgae Influence the Growth of Eastern Oysters *Chesapeake Bay Governor's School*

Aqua culturists can grow multiple species that benefit from each other synergistically to produce more goods at a lower cost. Using the native Eastern Oyster, *Crassostrea virginica*, for aquaculture, the oysters can improve the overall water quality of the Chesapeake Bay and boost adjacent ecosystems while increasing the abundance of the oyster population. Similarly, macroalgae acts as a carbon storage sink and can remove excess carbon from the oceans while simultaneously being a nursery habitat for fish. This study examined the potential of a growing symbiosis of *Crassostrea virginica* when paired with *Agardhiella tenera*. The *Crassostrea virginica* spat and *Agardhiella tenera* were each put into bags with oysters for two weeks in the water and length measurements of the oysters were taken. For the second experiment, initial water quality (pH, temperature, and ammonia levels) was measured from three 6-liter buckets with oysters added to produce metabolic waste. *Agardhiella tenera* was added to the buckets to photosynthesize and a final water quality was sampled. From the first experiment, comparing the growth rate of Eastern Oysters with macroalgae, the growth rate of macroalgae and oysters was 11.1% and 10.5%; the growth rate of oysters without macroalgae was 15.8% and 5%, these data were inconclusive, $p=0.275$; showing no significant change. For the second experiment, testing macroalgae's effect on oysters' water quality was significant, the t-test $p=0.0007$ showing significant change between the symbiosis of the oysters and macroalgae. This study concludes that *Agardhiella tenera* does not directly affect the growth rate of *Crassostrea virginica*, but the macroalgae does positively impact the water quality when paired with growing oysters.

ENV – Environmental and Earth Science -C

First Place

Davis Kildoo - A Cost-Based Risk Assessment of Climate Events for the Southeastern US

Chesapeake Bay Governor's School

Severe climate events threaten the health and wealth of the population in the southeastern United States. As climate events have become more destructive, the population and housing index has been increasing at the same time. In this study, the population data were gathered from 1970-2020 and the housing index data were gathered from 2014-2022, from coastal and inland cities: Norfolk and Richmond, VA; Dare County and Rock Mount, NC; Charleston and Columbia, SC; Savannah and Athens, GA; Miami and Orlando, FL. In addition, using National Oceanic and Atmospheric Administration (NOAA) risk mapping from severe storms, tropical storms and flooding from the preceding counties were assessed. Also, the monetary cost from severe storms, tropical cyclones and flooding were analyzed from: Virginia, North Carolina, South Carolina, Georgia and Florida from 2003-2023. A comparison of the growth of population, growth of housing index and risk mapping was conducted showing no statistical difference between coastal and inland cities. The monetary cost from severe weather events did appear to increase over time but was not a statistical increase.

Second Place

Libbie Hospodar - Examining Autochthonous Alternatives to Tropical Coconut Coir for Shoreline Engineering

Chesapeake Bay Governor's School

Living shorelines are "soft" engineering strategies that reduce erosion by reinforcing the coastal edge using structures built with natural materials like coconut fiber coir logs, instead of concrete, rocks, and rip rap for an organic stabilization solution. While coconut fiber coir logs are a great solution for erosion control in living shorelines in Virginia, coconut coir cannot be sourced anywhere near the location of use. In the Chesapeake Bay region, the use of more locally abundant, autochthonous materials like pine needles, corn crop residue, and the reeds of invasive *Phragmites australis* should be explored as replacements for coir. In order to determine the effects of weathering on the organic substrates, 15 bundles were manufactured per material, coconut coir, pine straw needles, corn stalks, and *Phragmites australis*, for a total of 60 bundles weighing around 40.00g. To determine the effect of the manufacturing method on degradation in the actual tidal estuarine environment, 27 additional bundles were manufactured using each

of the experimental materials. In both experiments, coconut coir outperformed the autochthonous materials and bundling methods. Coconut coir had the lowest average percent mass loss of -6.61% after the 24-week exposure period in the dry experiment followed by pine straw -15.91%. Similarly, for the wet experiment for manufactured biologs, the average percent change in mass was best for coconut coir at 4.04%, followed by the pine straw bales -5.51%, and the pine straw sock -6.86%, after the 8-week exposure period.

Third Place

Amina Khan -The Filtration of Microplastics Using *Lemna minor*
Central Virginia Governor's School for Science and Technology

The purpose of this study was to see if *Lemna minor* (duckweed) could be used as an effective, natural filter for cleaning water polluted with microplastics. Firstly, different petri dishes were created, each filled with an equal amount of water with the same number of microplastics in it throughout. Half of the petri dishes were designated for the duckweed to purify, and the other half was for the Brita filter. Water was simply poured into the Brita filter when draining its water, but the duckweed had to be removed before it was poured onto a grid paper, carefully cut to the size of a glass funnel, which was placed on a larger flask, attached to an air vacuum pump. The number of microplastics taken in by the duckweed filter and the Brita filter was recorded, and after averaging the quantitative intake, a two-sample t-Test was performed where a p-value of .0006 was produced. Considering the alpha value of .05, the p-value was much lower, conveying a statistically significant experiment. Although the hypothesis stating that there would be fewer microplastics remaining after the testing period in comparison to contaminated water using another filter, if *Lemna minor* (common duckweed) was added to the microplastic contaminated water, was not supported, the overall study showed remarkable results, which could be used in the future for larger research projects and worldly improvements.

Honorable Mention

Sage Lahmers - Relationship Between Below Ground Biomass and Soil Organic Matter:
A Case Study in Mt Tabor, Blacksburg
Blacksburg High School

The relationship between soil organic carbon and below ground biomass is a very important one. This study examined this relationship by sampling above ground biomass and soil organic matter. The null hypothesis was no relationship would be identified between soil organic matter and below ground biomass. The alternative hypothesis was that a direct relationship between soil organic matter and below ground biomass would

be observed. The above ground biomass was used to create an estimation of the below ground biomass. Using linear regression, it is possible to examine how closely this relationship may exist. 31 samples were taken along the Mount Tabor area of Blacksburg, Virginia. This specific area serves as a case study for what could be a broader relationship. However, further research would need to be completed to prove this. A low R-squared value of 0.031 was found, suggesting that there isn't a significant relationship present. There is also an examination of other factors that could relate to soil organic matter, such as soil type or slope. Many uncontrollable variables may have had outsized influences on the results.

Honorable Mention

Isabelle Hoover, Zainab Soofi, Lauren Kim - Discovering the effect of anthropogenic vibrations on the behaviors and development of *Artemia salina*
Governor's School @ Innovation Park

The increasing presence of noise pollution has had detrimental results on wildlife ecosystems and behaviors. In this study, vibrational noise will be applied to *Artemia salina*, or brine shrimp. With their fast-growing rate, necessity to the food chain, and their ability to survive in a myriad of environments, they are a foundation for aquatic life. They will be a representation of what could happen to future testing on larger aquatic species and ecosystems. The brine shrimp will be divided into a constant group and 3 affected groups that vary in the amount of vibration they are exposed to. The brine shrimp movement rates (mm/ms) had a significant difference between the tested groups and control group, with a p value <0.01 found with an ANOVA test. The length of the brine shrimp had slight to no significance found with an ANOVA test. However, the group with 3-hour vibration intervals was significantly varied in length, most likely due to their inability to respond to their ever-changing environment. Overall, we found a significant difference in brine shrimp's ability to survive and grow in an environment polluted with noise, which can correspond to further affects down the food chain.

Riya Jacob, Siri Gaddam - Enhancing the Nutritive Content of *Brassica oleracea* Using a Fruit Material Fortified Nutrient Solution
Academies of Loudoun

Over the past few decades, consumer trends have demonstrated a shift towards functional and organic foods grown without pesticides and agrochemicals. At the forefront of this trend are microgreens. These seedlings contain numerous phenols, flavonoid compounds, and essential vitamins. This study focuses on evaluating the nutrition profile of the *Brassica oleracea* microgreen; specifically, the concentration of anthocyanin compounds as well as the effect natural, recyclable additives have on this

compound within the plant. The optimization of growth techniques and supplementation have yet to be studied, and this review observes the potential effects of the addition of recyclable material. In addition, the growth of these microgreens will take place in a hydroponics system in order to mimic urban farming systems where land is scarce but nutritious vegetation is necessary. The initial evaluation of the microgreens demonstrated significant concentrations of anthocyanins within the microgreens making them an optimal plant for consumption to reduce neurodegeneration risk and provide essential compounds to the body. After harvesting microgreens grown with the addition of the recyclable additive, it was observed that the germination rate of the seeds and median length of the microgreens decreased. Numerous studies have seen reviewed the health benefits of microgreens, including their neuroprotective and anti-inflammatory properties making these plants an ideal addition to the daily diet. More research is needed to evaluate the possibility of optimizing specific nutrients within microgreens, and the effect that increasing a specific nutrient may have on other nutrients within the plants.

Emily Judy -The Effects of Different Types of Sunscreens on the Growth of a Dinoflagellate Mixture
Central Virginia Governor's School for Science and Technology

The purpose of this project was to look at the difference in various sun protection's contamination in the ocean. The study was conducted in a local high school laboratory during November of 2023. The materials used were a dinoflagellate mixture along with three different sunscreen brands including Sun Bum, Banana Boat, and Blue Lizard (all SPF 30). Each test group had seven trials each, including a control group. The absorbance was collected from each group once every week for three weeks using a spectrophotometer. Once the data was collected, the final absorbance and initial absorbance were compared to see the difference. The average change in absorbance was 7.14×10^{-4} , -0.395 , 4.29×10^{-4} , and 4.96×10^{-2} (Banana Boat, Sun Bum, Blue Lizard, and Control, respectively). A Single Factor ANOVA test generated a p-value of 6.68×10^{-16} , which is below the accepted alpha value of .05. A Tukey test then determined between which groups a statistically significant difference was shown. The Q_t value was 3.87 and the D_{min} was .0320. There was a difference between the control group and all three of my test groups (Sun Bum, Banana Boat, and Blue Lizard), as well as a difference between Sun Bum and Blue Lizard. This partially supported the research hypothesis, that Banana Boat would be the most harmful sunscreen to dinoflagellates. The results of this study suggested that all sunscreens were harmful to the dinoflagellates.

Diyaa Kirubaharan -The Effect of Sunscreen on Heart Rate of *Daphnia magna*
Mills E Godwin High School

The purpose of this experiment was to determine how each sunscreen impacted the respiratory rate of *Daphnia magna*. Since tourism has increased in coastal regions, the usage of sunscreen has also tremendously increased. Most popular sunscreens contain reef harmful chemicals like Oxybenzone. The hypothesis for this experiment is, if the Neutrogena Sunscreen is in the water, then the heart rate of the *Daphnia magna* will decrease the most. The control for the experiment is no sunscreen, and the levels of IV are Neutrogena Alba, Banana Boat, and Sunbum. One gram of sunscreen and 25 mL of tap water were mixed. Then 2mL of the solution was poured into half of the petri dish. Next, the solution was made again, and 2 mL was poured into the remaining petri dishes. Then each daphnia's heart rate was measured and placed in the Petri dish with the solutions. After an hour the heart rate was measured again, this was repeated with each sunscreen. According to the results, Neutrogena had the most impact on the respiratory rate of the *Daphnia magna*, and Alba sunscreen had the least impact. Neutrogena negatively affected the respiratory rate the most because it is a chemical-based sunscreen, and it contains nanoparticles that harm marine life. On the contrary, Alba sunscreen had the least impact because their sunscreens do not contain oxybenzone and Octinoxate and are 100% vegan. The t-test performed rejected the null hypothesis, which implies that the data was all significant.

Jacey Hendrix – Testing the Effects of the Sunscreen Ultraviolet Filter Oxybenzone on the Freshwater Plant *Lilaeopsis brasiliensis*
Southwest Virginia Governor's School

The ultraviolet filter oxybenzone is toxic to marine animal and plant life due to human contamination from the use of sunscreen. Recently, the use of mineral sunscreens that use zinc oxide and titanium dioxide has been promoted for ocean safety. However, the same advice is not widely expressed for recreational activities involving freshwater bodies of water like rivers and lakes. *Lilaeopsis brasiliensis*, a freshwater grass commonly known as "micro sword," was used to determine the effects of oxybenzone on freshwater plant life. The samples in the jars were designated into an oxybenzone sunscreen group, a mineral sunscreen group, and a control group, with four samples per group. Pure Sun Defense SPF 50 was mixed into the plant water as the oxybenzone sunscreen and CeraVe Mineral Face SPF 50 was mixed in as the mineral sunscreen. After the sunscreen application, the plants were observed after four days. The length of the plant's blades and roots were measured, as well as the overall health and color of the plant to be compared to the control group in a statistical analysis using an ANOVA test with a follow-up Tukey HSD analysis at the level of significance $\alpha = 0.05$. The

analysis determined both the mineral sunscreen and the oxybenzone sunscreen groups to be statistically significantly different from the control group in all measurements except for root length with p-values of 0.02 and 0.03 for blade length, 0.01 and 0.02 for health, and 0.01 and 0.01 for discoloration. The mean blade length for the control group was 1.73 inches compared to 1.16 inches for the oxybenzone sunscreen sample group and 1.19 for the mineral sunscreen sample group. The health levels for the control group averaged a 9 on a scale of 0 to 10 with 10 being the healthiest and the oxybenzone and mineral group averages being at a 6. These negative effects show how drastically the chemicals in sunscreen can destroy plant life at high levels. Research and testing are needed in the future to develop a safer sunscreen for both humans and the environment.

ENV - Environmental and Earth Science -D

First Place

Sriya Sridhar - Enzymatic Engineering for Enhanced Plastic Degradation in a Novel Plasmid System

Blacksburg High School

Each year, the world produces over 350 million tons of plastic waste, yet only 9% of this waste is able to be recycled. Much of this waste enters the environment as the microplastics MHET and PET, which are non-biodegradable. To promote the degradation of the MHET and PET microplastics, the objective of this project is to utilize the enzymes MHETase and PETase, which break down MHET and PET, to engineer a novel plasmid system to optimize the degradation of MHET and PET. Fine-tuning gene expression is used to alter the expression levels of MHET and PET, to explore the most optimal level for the greatest degradation. To build the plasmid, the MHETase and PETase enzymes will be removed from their plasmid backbone and inserted into four plasmid backbones, which vary in the strength of expression of the enzymes. MHETase and PETase will be inserted into the new plasmid backbones in replacement of a red fluorescent protein. The new plasmids with the MHETase and PETase enzymes will be transformed in an *Escherichia coli* culture. To analyze the results, the culture will be screened for the level of colony multiplication and the absence of the red fluorescent protein, which was present in the original backbone. The plasmid's successful transformation in the *E. coli* indicates the assembly of a novel plasmid, which could express the MHETase and PETase enzymes at a medium and strong rate, and therefore optimize the levels of plastic digestion to the greatest extent possible.

Second Place

Layla Leo -The Impact of Livestock Antibiotics on Marsh Microbes
Chesapeake Bay Governor's School

Salt marsh ecosystems play a crucial role in coastal community stability, providing essential ecosystem services. Microbial communities within these marshes significantly contribute to the overall health and productivity of the ecosystem. This study investigates the impact of antibiotics, particularly tetracycline, sulfamethoxazole, and ciprofloxacin, on bacterial communities in different salinity locations (oligohaline, mesohaline, and polyhaline) and marsh zones (low, mid, and high marsh) within the York River. Antibiotics, originating predominantly from livestock farming, can alter water quality and affect microbial communities. It was hypothesized that the polyhaline and low-marsh zones would have the greatest antibiotic resistance with the oligohaline and high-marsh zones having the lowest antibiotic resistance. Soil samples were collected from three salinity locations and three marsh zones within each location. The soil samples were serially diluted and plated on petri dishes. After incubation, the bacterial colonies were isolated and tested for antibiotic resistance for three antibiotic disks by measuring the ring of inhibition. The results reveal distinct antibiotic resistance patterns among bacterial colonies, with sulfamethoxazole exhibiting the highest resistance and ciprofloxacin exhibiting the lowest resistance. Salinity locations and marsh zones showed complex associations with antibiotic resistance, highlighting the intricate interplay of environmental factors. There were significant associations between salinity locations and antibiotic resistance. Additionally, there was a trending significant relationship between marsh zones and antibiotic resistance. The study emphasizes the need for further research to understand the ecological implications of antibiotic pollution on salt marsh microbial communities, vital for sustaining estuarine ecosystems.

Third Place

Pranav Sundarajan -The Effect of Citric Acid on Heavy Metal Rhizofiltration Efficiency
Mills E Godwin High School

Industrial activities have significantly elevated anthropogenic heavy metal pollution, leading to widespread ecological and health hazards. Rhizofiltration is a novel treatment method in which plants known as hyperaccumulators detoxify polluted water sources. This experiment aimed to investigate the effect of varying concentrations of citric acid on heavy metal rhizofiltration. In this study, copper was chosen as the heavy metal pollutant due to its widespread societal uses (as CuSO_4). Indian mustard seeds were germinated in a coconut-coir growth medium and transferred to a hydroponic set-up. The plants were exposed to CuSO_4 -contaminated nutrient solutions with varying citric acid concentrations: 0 ppm (control), 200 ppm, 400 ppm, and 600 ppm and left to decontaminate the solution for a week. The final copper content was measured using a

copper checker, and rhizo filtration efficiency was determined accordingly. It was hypothesized that if higher citric acid concentrations are added, then rhizo filtration efficiency would increase. The results indicated a direct relationship and showed that 600 ppm citric acid yielded the highest rhizo filtration efficiency. T-tests ($\alpha = 0.01$) revealed that the data was statistically significant. A possible explanation for the results is that citric acid converted into citrate anions, which bonded to Cu^{2+} (copper ions from CuSO_4). This would have formed mobile complexes (through a process known as chelation) that plants can better absorb than the copper ions alone. Further research should be performed on how other heavy metals (e.g., lead) and synthetic chelating agents (e.g., EDTA, DPTA) impact rhizo filtration.

Honorable Mention

Taylor Logan -The Effect of Temperature Stress on the Filtration Rate of 3 Different Bivalves

Chesapeake Bay Governor's School

The Chesapeake Bay is very susceptible to stress because of how shallow it is, and this allows the temperature to fluctuate very often. In the upcoming years, the temperature of the Bay could reach temperatures close to 31°C. When the Bay does reach this temperature because of climate change, will the Bivalves not only be able to survive, but maintain the health and different ecosystems of the Bay? This study was conducted to see the effect that rising temperatures would have on the different bivalve's ability to filter water. For the study, local Chesapeake Bay hard clams, mussels, oysters, sediment, and water were placed in to 15 containers of the same dimensions. Water samples were taken every 25 minutes and placed into the spectrophotometer for each trial to measure their filtration rate. ANOVA tests were run on each trial and the p-value for the 90-minute time marker at 22 degrees Celsius was 3.157×10^{-10} while the p-value for the 90-minute time marker at 31 degrees Celsius was 3.0048×10^{-10} , indicating that there was a significant difference in filtering of the different bivalves at the end of both trials. For the room temperature water trial mussels filtered the best and a Tukey's post hoc test showed that all the groups filtered significantly different from each other except for when directly comparing clams to the control, mussels to oysters, and oysters to all 3 together. For the heated water trial oysters filtered the best, the Tukey Post-hoc test showed that all the groups filtered significantly different from each other except for when directly comparing clams to oysters. Since the oysters did the best at making the water clear in the heated water trial, could it be worth spending the extra money on restoration efforts for them in the Chesapeake Bay?

Honorable Mention

Christopher Ransone - Prevalence of Macroparasites *Polydora websteri* and *Zaops ostreus* within *Crassostrea virginica* in Varying Environmental Conditions.
Chesapeake Bay Governor's School

Crassostrea virginica, the Eastern Oyster, serves as a keystone species within the Chesapeake Bay and has been well established in the aquaculture industry and livelihoods of many people in the commonwealth of Virginia and beyond. However, numerous studies have been calling attention to the mud blister worm, *Polydora websteri*, threatening the health and marketability of the Eastern Oyster. The shell boring parasitic polychaete leaves behind unaesthetic and detrital filled blisters in the bivalve's shell, threatening product edibility. Infection with the parasite may also potentially leave the oyster weak and susceptible to predation and infection of other macroparasites, such as the oyster pea crab *Zaops ostreus*. This study examined two-hundred fifty oysters across five locations in Virginia for prevalence of *P. websteri* and *Z. ostreus* in varying salinities and temperatures, in efforts to investigate correlation amongst macroparasite populations in relation with each other and in varying environmental conditions. All oysters contained *P. websteri* parasitic intrusions at varying degrees, and 19.2% contained *Z. ostreus*. *P. websteri* prevalence significantly increased in oysters found in warmer and less salty waters, noted by an ANOVA test yielding a p-value of 0.0023. *Z. ostreus* prevalence also significantly increased with a p-value of 1.18E-08 as temperature increased and salinity decreased. As climate change and ocean acidification impacts the aquatic ecosystem, changing water quality parameters may directly impact *C. virginica*, and its ability to resist macroparasites, that in turn may impact the health of the bay and those who rely on it.

Honorable Mention

Mary Ann Zyglocke Impact of Different Levels of Sunlight on Dissolved Oxygen Produced by *Elodea canadensis*
Collegiate

The dissolved oxygen concentration of a body of water can be an indicator of its overall health and quality. A body of water can receive dissolved oxygen in two ways, but the majority of oxygen comes from photosynthetic aquatic organisms. As these organisms photosynthesize, they produce oxygen as a byproduct, and it is released into the water. Higher levels of dissolved oxygen can indicate a healthier environment because the levels of dissolved oxygen can reflect the health and fitness of aquatic organisms in a body of water. Research suggests that temperature is one factor that can alter dissolved oxygen concentration. It has been found that temperature is inversely proportional to

dissolved oxygen concentration. There is a gap in the literature on dissolved oxygen because two studies conducted by Dick and colleagues (2016) and Arbib and colleagues (2017), found increased dissolved oxygen levels during the warmer months of the year. These findings suggest that there are other factors that alter dissolved oxygen concentration, and one of these factors could be sunlight. The present study examines the effect of sunlight on concentration of dissolved oxygen. In this study, six beakers were filled with water, and an aquatic plant, *Elodea canadensis*, was placed in each beaker. Plants were monitored over a three-week period, and dissolved oxygen levels were measured ten times throughout the experiment. Dissolved oxygen was measured in mg/L using a dissolved oxygen probe. Once the experiment concluded, a One-Way Analysis of Variance test was performed, and it showed that there was a statistically significant difference between groups. This data suggests that there is a relationship between sunlight exposure and dissolved oxygen concentration, and it is consistent with the findings of Dick and colleagues (2016) and Arbib and colleagues (2017). The results of this study provide data that shows how multiple factors can affect the concentration of dissolved oxygen in a body of water. This provides information that can help deepen the understanding of how dissolved oxygen works, and the effect it can have on an aquatic ecosystem.

Emma Matos -The Effect of an Adsorbent Raw Bamboo Filter on a Sustainable Removal of Methylene Blue Dyes from Wastewater
Mills E Godwin High School

Wastewater treatment is vital in procuring clean and sanitary water, as well as protecting the environment and its ecosystems for a healthy, thriving earth, free of toxins. However, with a growing textile industry, dyes infect wastewater with toxic, carcinogenic, and mutagenic properties. Current treatment facilities for wastewater are inefficient, and expensive, and often end up doing more harm than good. Cellulose adsorption is one of the only economically feasible, uncostly, and renewable options, and is also insoluble in most solvents because of its crystalline structure and hydrogen bonding. Moreover, it was hypothesized that if a solution of methylene blue were run through a thick layer of cellulose, then more MB would be filtered. Despite this, it was also predicted that at 4 mm of cellulose, the permeability of the filter would decrease. After the construction of the filter using sustainable materials and the extraction of cellulose from *Phyllostachys Aurea* bamboo, a spectrophotometer was used to determine the photons absorbed at each wavelength. After data collection, a t-test revealed the data to be statistically insignificant. Therefore, the hypothesis was not supported, and the null hypothesis could not be rejected. It is believed these results are due to experimental error, including the type of bamboo and the method of extracting the cellulose. This research could lead to further studies that investigate the relationship between the amount of cellulose and

adsorption, or even other areas in which cellulose can effectively be used as treatment for a deteriorating environment.

Cameron Micket - Fighting Global Warming's Evil Twin: A Study on Alkalinity and Calcium Buffering Capacity in the Lower Chesapeake Bay
Chesapeake Bay Governor's School

Many people have heard of global warming but not as many people have heard of its "evil twin", ocean acidification, which is causing harm to our coastal ecosystems. There are two main causes of coastal and ocean acidification: globally the greatest cause is due to the large amounts of carbon dioxide (CO₂) that are being produced from the burning of fossil fuels. CO₂ in the water leads to ocean and coastal acidification and an unstable living environment for organisms like the Eastern Oyster, *Crassostrea virginica* and many other bivalves. Oysters are calcareous organisms that need calcium ions (Ca⁺²) and carbonate ions (CO₃⁻²) to build their shells. The acidified lower pH water starts to change the water's carbonate chemistry. The sample sites selected were Warehouse boat ramp on the Ware River, Deep Point boat ramp on the Piankatank River, and Gloucester Point boat ramp on the York River. Once at a sampling site, the test water was collected, and the water temperature was recorded. A total of 18 samples have been tested from the three testing sites combined. Comparing the three sites to each other across the study period using an ANOVA test found that the levels of pH, calcium, and salinity were all statistically significantly different by site. The results from this study show that calcite concentration does change over space and time. This study found that Alkalinity does vary in space and time but not enough to be statistically different.

Meilin Ranjan – A Pollution Distribution Confusion: Socioeconomics of Microplastics Contamination in Virginia Beach, VA Waterways
The Mathematics and Science Academy at Ocean Lakes High School

Monetary expenses and a lack of standardization in microplastics analysis have limited our ability to quantify the abundance and understand the distribution of an emerging pollutant in waterways across the globe. This study aimed to assess an adapted method for microplastics detection which relied solely on equipment available in most secondary school science classrooms, and to utilize it to analyze the relationship between microplastics contamination and economic status in the Virginia Beach, VA area. The analytical method consisted of relatively straightforward steps of freshwater sampling, mechanical filtration, wet peroxide oxidation, and density-based separation followed by a novel carbol fuchsin staining test which allowed for identification of polypropylene. It was

hypothesized first that the procedure followed could allow for nonconsumptive isolation of waterborne microplastics and that the carbol fuchsin staining and fluorescence analysis could successfully differentiate PP from other plastic contaminants. Additionally, it was predicted that neighborhoods of higher economic standing in the Virginia Beach, VA area would experience lower levels of microplastics in their waterways. The retention of known microplastics in the positive control sample throughout the analytical process, coupled with the positive results of the carbol fuchsin staining test, appeared to support the first claim. The predicted economic trend was observed for one of four economic indicators considered (median household income in corresponding census tract), providing an inconclusive result. Further analysis with larger data sets and wider ranges of mathematical methods must be conducted for greater certainty and generalizability.

ENV - Environmental and Earth Science – E

First Place

Caitlin Murphy - Exploring the Use of Reclaimed Eutrophic Water for Growing Butterhead Lettuce (*Lactuca sativa* var. *capitata*) in a Hydroponic System
Chesapeake Bay Governor's School

Eutrophication, which is the accumulation of excess nutrients in a body of water, is a phenomenon that is detrimental to humans and aquatic ecosystems alike. Traditional farming is a major source of eutrophication, as fertilizer and animal waste runoff are leading contributors to nitrates and phosphates in aquatic habitats. As a result, non-traditional methods of farming are increasingly emphasized to decrease environmental impact. One of these methods is hydroponics. Hydroponics is a soilless cultivation method that utilizes water with an artificial nutrient solution to grow plants without the pollution of traditional farming. Using a nutrient solution is the standard method with hydroponics; however, it was hypothesized that a hydroponic system using reclaimed eutrophic water would have the same or a greater rate of plant growth as a conventional hydroponic system. Growth of lettuce was measured by the plants' height, leaf length, and biomass before and after exposure to two different treatment groups: a conventional hydroponic system with water and artificial nutrient solution, and an experimental hydroponic system with only reclaimed water. The experimental group outperformed the control group, which implies that eutrophic water can be used in hydroponic systems to grow crops effectively. The study found that the experimental group had a statistically highly significant difference in mean plant height, leaf length, and biomass measures. This experiment served as a proof-of-concept study to

determine the feasibility of reclaimed eutrophic water in hydroponic systems; future studies could expand upon these initial findings in subsequent applications.

Second Place

Barathi Saravanan -The Effect of Hydrocolloid Edible Coatings on Ripening of Bananas
Mills E Godwin High School

As the most popular fruit in the world, 117 million bananas are produced annually. Out of the total, 43% of the fruits are disposed of due to the extremely short shelf life. As a result, scientists have been exploring the possibility of edible coatings, which are eco-friendly unlike their polyethylene counterparts. The purpose of this study is to determine which cost - effective polymer results in the most efficient edible coating that extends the shelf life of bananas. Guar gum, xanthan gum, and gelatin were chosen as hydrocolloids used in the edible packaging due to their accessibility. A slurry of 200 mL water, 3 grams hydrocolloid, and 2 drops of glycerin was stirred over the heat until slightly thickened. The weight of unripe, green bananas was measured using a weight scale and they were dipped into the hydrocolloid mixture and left to dry. The weight was measured every day, and the data was recorded to analyze. The results showed that guar gum was the best hydrocolloid coating as it prevented the weight loss of the bananas. However, all of the coatings were proven to be effective due to the data being significantly different from the null hypothesis. The research hypothesis stated that if gelatin was used as a coating for bananas, then they would maintain freshness for the longest period of time. It was not supported since guar gum was the most effective polymer. The mean of all the coatings except for the control was 15%, while the control was 16%, proving the functionality of the coatings. The variation was less than one, and the t-test performed showed that all of the independent variables were statistically significant. The ability to create a semi-permeable barrier may have been the reason that guar gum was the most successful hydrocolloid. Sources of error present in the experiment might have been the change in conditions (temperature, humidity, etc.) as the seasons changed and discrepancy in the thickness of the coatings due to temperature. These possible errors could be avoided by performing the experiment in a laboratory with controlled conditions. Further exploration into the realm of polymers include using different plasticizers and trying different concentrations of hydrocolloid.

Third Place

Lily Ohlschlager - *Hydrilla verticillata* in the Chickahominy River- Are All Invaders Really Bad?
Chesapeake Bay Governor's School

Invasive species are a costly recurring problem throughout the United States and put native plants and animals at risk. An aquatic invasive species that dominates many bodies of water in Virginia is *Hydrilla verticillata* (Hydrilla). Hydrilla was first introduced into the U.S. in the 1960s and was first spotted in Virginia in 1982. Some studies have shown the negatives associated with Hydrilla, while others have shown a range of positive attributes. In this study, a submerged aquatic vegetation (SAV) grass bed in the Chickahominy River in New Kent County, Virginia was identified as containing Hydrilla verticillata and other different types of native aquatic plants living together. These SAVs were harvested and tested in experiments with a low dose of 3.0 ppm and a high dose of 8.0 ppm fertilizer treatments to look at the absorption rate of ammonia (NH₃). There was not a significant difference in the composition of grasses by weight in samples, indicating that invasive Hydrilla cohabitates harmoniously with the native species, $p=0.2205$. Results also showed that all four SAV types tested in both fertilizer treatments had a significant difference in the NH₃ absorption compared to the control group; $p\sim 0.05$ in low-dose treatment and $p<0.05$ in high-dose. When comparing Hydrilla NH₃ absorption to the native SAV, the p values reveal that invasive Hydrilla outperformed the native SAVs that were tested with $p>0.05$ in the low-dose treatment and $p<0.05$ in the high-dose treatment.

Honorable Mention

Aarav Nayak -The Effect of Different Oil Filters on Oil Filtered
Mills E Godwin High School

The experiment aimed to determine the most effective method of filtration for oil in water. The hypothesis was that the PIG filter would filter out the most oil. The investigation tested independent variables, including the PIG filter, Charcoal filter, Sand filter, and Dawn Dishwashing Detergent. After conducting trials, the density of the remaining mixture was calculated using the beakers and kitchen scale. The inferential statistics table showed that the Charcoal vs. Sand independent variables were insignificant. The rest of the variables were significant with a calculated t -value of 2.407, supporting the hypothesis. The raw data showed that the PIG and Charcoal filters performed similarly. Future experiments could investigate environmental factors affecting the preferred filtration method.

Honorable Mention

Eva Siminiceanu -The Effect of Decreased Environmental pH on the Rate of Clam Filtration
Collegiate

Climate change is a significant issue in the modern world, and many types of ecosystems have been and will be affected by it. In aquatic environments, the issue of ocean acidification, or the process by which increased atmospheric CO₂ raises the amount of carbonic acid in the ocean, is increasingly threatening a variety of organisms as well as the chemical balance of the ocean. Calcifying organisms, or organisms with shells made of calcium carbonate, have a significant role in maintaining the chemical balance of the ocean, and filter feeders, like clams, play the important role of clearing particles and algae from the surrounding water and depositing a dense waste product. The objective of this experiment was to observe and quantify the effect of ocean acidification on the ability of calcifying Mercenaria clams to filter waste out of their environments. The ultimate objective is to understand the larger implications of ocean acidification in the wider context of aquatic ecosystems that are dependent on filter feeders. For this experiment, pH levels of 8.20, 8.15, 8.10, 8.05 were considered and the rate (NTU/hr) at which the clams cleared the water through their filtration mechanisms was collected and measured for each level. These levels were based on the pre-industrial pH of the ocean, the current pH of the ocean, and one level lower than both of those to account for a future pH of the ocean when ocean acidification continues. Clams were placed in beakers filled with sand and ocean water to simulate the ocean environment and the beakers' pH was reduced to the determined values, and the rate of change of the turbidity at each level was calculated using a best-fit trendline of a series of turbidity measurements taken at different times. Although there were some threats to validity such as errors with instrumentation and confounding variables originating from having live clams, a positive correlation between the variables was observed. As the pH decreased, the rate at which the clams decreased the water decreased in magnitude as well. R² values obtained showed that the calculated slopes had a variety of adherence to the original data. Ultimately, the data did not produce statistically significant results, but the trends observed suggest that future studies on this topic conducted over a larger period of time with more levels could yield statistically significant data reinforcing the observed trend. This study should be repeated to ensure that the results are reproducible and significant. Additionally, there are lots of potential studies and questions centering around other observed issues such as the amount of calcium carbonate in each beaker and the change in color of the clams over time.

Weston Smith -The Influence of UV-A & Infrared Exposure on The Reproductive Capabilities of The Cyanobacteria of Southwest Virginia
Southwest Virginia Governor's School

Cyanobacteria is a vital aspect to all living organisms; however, it can also be detrimental to society if left to die or bloom uncontrollably. Therefore, understanding how different wavelengths and types of lights affect cyanobacterial growth is imperative. Though many

researchers have studied the effects of commonplace lighting on cyanobacteria, many stray away from the more complex nature of UV-A and infrared light. The objective of this study is to determine if UV-A and infrared light significantly impact the growth of cyanobacteria; to examine this question, three cyanobacteria treatment groups (with 6 samples each) were constructed: UV-A, infrared, and control (plant growth light). The treatment groups were incubated for five days each and growth readings were recorded daily using Spectro-Vis Spectrophotometry. The differences in growth were calculated and averaged for each treatment group then analyzed by an ANOVA and Tukey HSD test for statistical significance; the results of the two tests suggested statistical significance in the growth of the UV-A (p-value = < 0.0001) and infrared (p-value = 0.0007) treatment groups. A linear regression was then used to determine a correlation between algal growth and light exposure duration; the linear regression found no statistically significant correlation between growth and exposure time in any of the three treatment groups. The data suggests that UV-A and infrared radiation do significantly affect algal growth, in a positive manner; however, there is not a direct correlation between the two factors. Future studies should further study the correlation between UV-A and infrared light, in comparison to algae growth, in order to better understand and predict the growth rates of algae; this will increase our ability to control, predict, and maintain stable algae populations.

Sophia Ng – The Effect of Pollution History in Different Bodies of Water on pH and Wildlife Present.

Mills E Godwin High School

This paper was a product of experimenting on different polluted bodies of water and measuring their pH and organisms over the course of a month. Looking at different areas of polluted waters and measuring pollution's effect on these waters can help us understand the extent of the damage and help produce solutions to fix the damage we have caused. The water was collected into containers and brought back to a microscope and desktop for testing. pH strips were used to record the pH of the water and using a microscope the number of moving organisms counted in 30 second intervals was recorded. All data was placed on a spreadsheet. This entire process was repeated for 25 days in total. It was predicted that Tuckahoe Creek would have the most "unnatural" pH and least number of organisms. The results showed that Tuckahoe Creek had the highest pH of the three IV levels, but Stony Run had the least number of organisms. A t-test was completed on the data for pH and yielded that all data was significant except for Deep Run vs. Stony Run. Chi-square tests were run on the number of organisms, and it showed that all data was significant. These results, however, did not support the original research hypothesis. Similarly, literature suggests that areas of high pollution rates suffer from lower levels of oxygen present in the water leading to below average

numbers of diatoms and amoeba in the area. Further studies can be conducted on how places with a healthy ecosystem and less pollution in the past compared to those with heavier pollution rates.

Tristan Fields -The effect of *A. platensis*-containing water-like growth mediums on pH variation

Mills E Godwin High School

The purpose of this experiment was to determine if *A. platensis* can cause a pH change in its environment and which environments *Spirulina* causes the most consistent pH change. The reasoning used for this experiment was to determine the ability of *Spirulina* to alter the pH of the surrounding environment. This experiment could imply a potential solution to Ocean Acidification. One hundred test tubes were filled with four different growth mediums, distilled water (control), Springwater, Freshwater growth medium, and Seawater growth medium and five drops of the *Spirulina* solution from Carolina Biological Supply and the test tubes were left out in light and exposed to the air at room temperature for a week. The hypothesis used was that if the Freshwater growth medium were used to grow *Spirulina*, the pH would increase the most. The results showed that the Springwater solution had the highest positive pH positive, and the Freshwater growth medium had the highest negative pH change. A T-test was conducted on the data and showed that the Freshwater growth medium was not statistically significant, and the rest of the data was significant. The data did not support the research hypothesis and the results gathered were not known to have been caused by an external force but could have been due to unaccounted factors between the growth mediums, like differing salinities or initial pH. This could lead to more studies on the effects of runoff and hydrothermal vents on CO₂ fixation of *Spirulina*, and other photosynthetic microbes and extremophiles.

Jack Schrader -The Effect of Land Gradients on Erosion Risk

Central Virginia Governor's School for Science and Technology

The purpose of this project was to learn more about the relationship between the slope of land and the risk of erosion on it. This information would allow for public trails to be built in more sustainable locations. This project included the use of an erosion database from a public organization, which documented the slope and erosion risk of thousands of

plots of land in a national park. The data set used was then further organized into four categories of slope gradients and three categories of erosion risk. Major characteristics of the data set included the fact that steeper land gradients were more common than gradual ones, and that greater erosion risks were more common than slighter ones. The data was analyzed for statistical significance using a Chi-Square Test for Independence, with an alpha value of .05. The test returned a p-value of exactly 0, and the research hypothesis that higher slopes would result in greater erosion risk was strongly supported. Overall, this study reinforced an arguably predictable pattern with an extremely confident result. This result could be used to build more sustainable and environmentally friendly public trails, preserving both natural beauty and the public's access to it.

ENV - Environmental and Earth Science -F

First Place

Caroline South - Effect of Digestive Enzymes on Cellulose Microplastics

Individual

This experiment was conducted to test the effect of digestive enzymes on cellulose microplastics. The hypothesis for the experiment was if different digestive enzymes are exposed to cellulose microplastics then amylase will be able to break down the most microplastics because amylase is responsible for most of the breaking down of carbohydrates in the digestive system, and cellulose microplastics is mostly made of cellulose, which is a carbohydrate. The tested groups were protease, amylase, lipase, and water, which was the control. Fifteen trials per group were tested by exposing 10mL of each solution to approximately two grams of microplastics, and then leaving the combination in a petri dish for three days. An ANOVA test showed statistical significance with a p-value of 4.62×10^{-17} . A T-test was conducted to test the statistical significance between the amylase and the lipase, and the T-test concluded that there was statistical significance with a p-value of 0.0178. The experiment supports the hypothesis that microplastics exposed to amylase have the greatest percent decrease. Amylase had a mean percent decrease of 27.39. Lipase had a mean percent decrease of 20.18, followed by protease with a mean percent decrease of 14.55, and then water, the control, with a mean percent decrease of 4.78.

The experiment is important in determining the decomposition of microplastics in the digestive system. It could be expanded to look at biomagnification of microplastics in organisms and improved by using a spectrophotometer.

Second Place

Charlotte Phillips - Investigating Degradation of Polyhydroxyalkanoate Straws in Saltwater Environments with Varying Temperatures, and in Presence of *Turbo marmoratus* and *Lysemata wurdemanni*
Southwest Virginia Governor's School

Regular plastic straws use causes harm to marine organisms. Polyhydroxyalkanoate (PHA)/phade® straws are an alternative, with similarities in texture, convenience, and cost. The manufacturer claims phade® straws fully degrade in 58 days. This project investigated this claim and how extensively phade® straws degrade in ocean environments of varying temperatures in the presence of *Turbo marmoratus* and *Lysemata wurdemanni*. Materials (PHA=phade® straws, regular plastic straws as negative controls, and acetate sheets as positive controls with n=32 per group) were tested in aquaria simulating temperatures of 20oC (Atlantic=A), 22oC (Indian=I), and 24oC (Pacific=P). After 46 days, percent of mass loss and force to break were determined. ANOVA demonstrated significantly different degradation of phade® straws versus regular plastic straws and acetate sheets within each temperature ($p < 0.0001$ for both mass loss and force to break). PHA/phade® straws had significantly greater mass loss (A:31.6 $\pm$ 1.3, I:41.8 $\pm$ 1.2, P:31.5 $\pm$ 0.6) for mean $\pm$ SE compared to acetate (A:15.6 $\pm$ 0.6, I:8.9 $\pm$ 1.8, P:13.5 $\pm$ 1.7) and regular plastic straws (A:-2.9 $\pm$ 0.99, I:1.56 $\pm$ 0.7, P:-0.27 $\pm$ 0.98); Tukey HSD analysis yielded $p < 0.0001$ for each comparison. PHA/phade® straws required significantly less force to break (A:6.5 $\pm$ 0.6, I:7.4 $\pm$ 0.4, P:7.7 $\pm$ 0.3) compared to acetate (A:3.2 $\pm$ 0.3, I:3.9 $\pm$ 0.2, P:3.4 $\pm$ 0.2) and regular plastic straws (A:13.2 $\pm$ 0.1, I:13.3 $\pm$ 0.01, P:13.0 $\pm$ 0.0.1); $p < 0.0001$ for Tukey HSD comparisons. These results demonstrate significant PHA/phade straw biodegradation. In future research, the student will continue GC-MS analysis to identify degradation products present in water from the test tanks. Initial GC-MS trials indicate PHA degraded primarily to surfactants and fatty acids consumable by marine microbes, supporting PHA as a useful biodegradable material for use in creating eco-friendly single-use items.

Third Place

Sakeena Saidou - A Call to Action! Changes in Glycine max Photosynthesis Rates According to UV-B Intensities
Central Virginia Governor's School for Science and Technology

Over the past few years, it has become more evident the crisis that is the depletion of the ozone layer. Ultraviolet-B radiation has the potential to drastically change the health of all living things on Earth. The purpose of this research was to focus on the effects an increase in UV-B exposure has on plants, more specifically Glycine max which is more commonly referred to as soybean, by collecting photosynthesis rates. Three groups of Glycine max were exposed to different UV-B intensities. The development of each group was observed over a two-week period and then the testing period began that involved a floating leaf disk assay technique. By creating a vacuum with a syringe, the oxygen was taken out of hole punches of the leaves. The chads, or the hole punches, were then placed in a solution of 100 mL of water to 1 gram of sodium bicarbonate, or baking soda, to replicate carbon dioxide. The time it took for each chad to float back up was recorded. The research hypothesis stated that if Glycine max is exposed to different UV-B radiation intensities, then the lowest intensity will exhibit the most effective photosynthesis; A Single Factor ANOVA gave a p-value of 2.41×10^{-13} which called for a post-hoc test with a Dmin value of 19.266. Data supported the research hypothesis, that the group exposed to the full spectrum bulb had the best photosynthesis rates.

Honorable Mention

Olawande Oluwaji - Filtering Efficiency of *Daphnia magna* in Response to Low and High Anabaena Concentrations

Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if differing concentrations of algae (Anabaena) had an effect on the filtering capability of *Daphnia magna*. The research hypothesis stated: if *D. magna* is placed in an aquatic environment with a high concentration of Anabaena, then its filtering efficiency will decrease. Approximately 1.5mL of algae were each placed inside seven beakers with five *Daphnia* specimens for the low concentration set, which lasted for a week. After collecting data, seven high concentration trials began with the same number of algae, *Daphnia* specimens, and time. The control groups were measured for the two concentrations, which only measured the algae without *Daphnia*. The change in Anabaena absorbance for both high and low concentrations were calculated by subtracting the initial from the final absorbance. A single factor ANOVA determined significance, with an alpha level set at .05, revealed a p-value of .023. A post hoc Tukey test then determined groups that the significance was held, with a Dmin of .126. The means were 0.259 for the control, 0.062 for the low concentration, and 0.008 for the high concentration. There were significant differences between the control group compared to the high and low concentration. To conclude, there were no statistically significant differences between the high and low concentrations; however, the hypothesis was partially supported, as *D. magna* filtering

efficiency decreased when exposed to high concentrations of *Anabaena*. In conclusion, higher *Anabaena* concentration had no significant effect on the filtering efficiency of *D. magna*.

Arnav Shrestha -The Effect of Algae Species Simulated Growth on Carbon Dioxide Reduction Efficiency
Mills E Godwin High School

The purpose of this experiment was to test different autotrophic green algae in a simulated natural environment biome to the amount of oxygen produced and carbon dioxide reduced. The research is important to the real world due to its potential for atmospheric carbon dioxide reduction. With solutions to carbon dioxide reduction being formulated, one natural way CO₂ is regulated can be through plants, specifically algae. The various species are *Microspora*, *Mougeotia*, *Spirogyra*, and *Zygnema* algae. An environment with no algae to be simulated was the control group. It was predicted that *Microspora* algae would be the level of IV that produces the most dissolved oxygen levels in the simulated environment. A simulated plastic environment was constructed with a plastic tank with a slot hole for carbon dioxide and oxygen probes. A base oxygen amount of 5 mg/l was placed in the environment. Along with this, carbon dioxide was placed in the environment with a carbon dioxide bike pump carbonator. Algae was placed at the bottom of the environment along with some water for the algae to grow. The algae were simulated with a UV light shining based on night and day. The initial and final oxygen and carbon dioxide amounts were taken and averaged. When comparing the data's central tendencies, it can be seen that *Spirogyra* had the greatest mean of 6.164 mg/L. When conducting the t-tests, *Microspora* vs *Mougeotia* had a t-test value of 0.183, which is lower than the critical value, which was the only value lower than the critical value. This means that $p > 0.05$. For this comparison, the null hypothesis failed to be rejected, meaning that the data is not statistically significant. Every other calculated value was greater than the critical, making $p < 0.05$. This indicates that the data rejected the null hypothesis, and that the data is statistically significant.

William Ochoa - Using the Most Common Food Waste in America to Produce biogas
Chesapeake Bay Governor's School

As the human population continues to grow and technology continues to advance three large problems grow with them. These three large problems are climate change,

possible energy crisis, and wasted food. Human population increasing exponentially has resulted in production of more technology, food, and other necessities. Along with this need for more production comes more wasted food and a larger consumption of energy which humanity is trying to produce in a more environmentally friendly way in hopes of combating climate change. This has led to energy companies moving to renewable energies like wind, solar, water, biofuels, etc. Even though these energy companies are reducing lots of emissions by switching to more renewable sources of power there are still many other large pollution producers one of them being from our waste mostly in landfills. This research project focuses on if most of the food that is wasted in the world can be turned into a biogas without disrupting or lowering the Biogas production. During this research project four of the most wasted foods in America were used which included milk, bread, fruits and vegetables, and meat. Each of those foods were placed into their own biodigester and the gas produced was measured. Along with those four biodigesters a fifth biodigester containing an equal portion of all the other foods was made as a constant. This study did show that biogas can be made from the most wasted food items without completely disrupting the production of biogas. This study is important because it can help give proof to investors that this will solve many problems like reducing pollution, fighting the upcoming energy crisis, and turn large amounts of waste into something useful all while still being profitable.

Anika Parashar -The Effect of Different Substrates on the Efficiency of a Waste-Based Microbial Fuel Cell
Individual

Food waste takes up 22% of space inside US landfills, however, some percentage of this waste could be used to produce clean energy. Microbial Fuel Cells (MFCs) are devices that harness electrical energy from microbial metabolic processes, such as anaerobic respiration, where electrons are released as a byproduct. The electron flow causes an electric current. The objective of this research was to evaluate the effects of two different substrates on the efficiency of an MFC. Prior research shows that orange peels have a greater concentration of *P. fluorescens*, because of this orange peels are likely to be the most efficient substrate. The independent variable was the substrate (orange or lime peels), the dependent variable was the voltage output, and the control used distilled water as the substrate. Salt agar was prepared using agar powder, table salt, and distilled water. Fruit peels were blended with distilled water for the substrate and two pieces of aluminum mesh were folded onto one piece of braided copper wire and put at the bottom of each chamber to harness electricity. A salt bridge was used to connect the two chambers. The food waste was in the anode and the tap water was in the cathode. A multimeter was used to measure the voltage. The results showed that lime peels had the most electrical output, but the experimented hypothesis was not

supported. This research can be implemented on a large scale by utilizing waste in the juice industry to produce energy.

Samantha Winter The Effect of Rain on Stream pH
Mills E Godwin High School

The purpose of this experiment was to observe the change of stream pH over time and determine the effect of rain on stream pH. This was done by collecting samples of stream water and testing their pH before and after rain. These results were then used to determine the effect of rain on stream pH. In order to collect these samples, a jar was lowered into the designated stream and filled with water. This water sample was then tested with a cleaned and calibrated pH tester and the data was recorded. Samples were taken every day before and after rain for the duration of the experiment. A t-test was used to determine the significance of the data collected. It showed that all the data collected 1, 2, 3, and 4 days before rain and the data collected 3 and 4 days after rain were all significant compared to the day of rain. The probability of error for these levels of independent variable was less than 0.05, meaning the data was statistically significant. The data from 1 and 2 days after rain were not statistically significant with a probability of error greater than 0.05. The data showed that rain caused a short-term decrease in stream pH.

MTM - Mathematical Theory & Modeling

First Place

Angelina Guo - A Highly Accurate Detection of Glaucoma with Neural Networks - A Case Study for Early Detection
Central Virginia Governor's School for Science and Technology

Glaucoma is a neurodegenerative eye disease that causes irreversible vision loss due to a damaged optic nerve. It is the second most common cause of blindness worldwide, and over 3 million Americans are affected. Convolutional Neural Networks (CNNs), a type of artificial deep-learning neural network, have been widely used in medical images for the purpose of image classification, segmentation, localization, and detection. This research study aims to develop a CNN model/algorithm that allows for early detection and diagnosis of glaucoma disease. The proposed CNN model has been trained by a public fundus image dataset (ACRIMA) and achieved a high accuracy, precision, sensitivity, specificity, and F1-score. The test results indicate that it is highly possible to implement the proposed CNN model for early detection of glaucoma.

Second Place

Shriya Bandla - Using Modeling Techniques to Predict the Likelihood of Heart Disease
Mills E Godwin High School

Heart disease is the leading cause of death globally. By catching heart disease risk early, more people will be able to live their lives without heart disease and its impacts. The model used in this experiment will be created using Python. The model is a convenient tool, people can see how their lifestyle effects their risk for heart disease. When inputs are given, the risk of heart disease can be calculated by the model. The purpose of this experiment is to determine a model to accurately predict the risk of heart disease based on risk factors. Several heart disease risk factors were considered including age, sex, chest pain, cholesterol, blood sugar, resting blood pressure, and max heart rate. The variance and standard deviation were calculated for each of the levels of the independent variable. The standard deviation was relatively low for each level of the independent variable, implying the data sets were tight and precise. One of the data points for the independent variable was outside the SD 2 range, implying that there was one outlier. The accuracy of the model was used to determine how accurate the results in the model were. The best accuracy of the model was found when 65% of the data was used as test data and 45% was used to train the model. The mean accuracy was determined of the data set to be 74.33%. This can be improved by using more data.

Third Place

Devesh Kumar - An Ensemble Approach for Improving Model-Based Reinforcement Learning in Robotic Control
Individual

Deep Reinforcement Learning (DRL) has become a critical part of 21st century technology, especially when dealing with complex and sequential decision-making problems, whether its robotics or gaming. Traditional DRL methods are often limited by having inefficient samples, difficulty in long-term planning in long-horizon tasks, and, most critically, difficulty creating effective policies for unseen environment states. Model-Based Reinforcement Learning (MBRL) is a solution that provides greater efficiency, but limited ability to make predictions on unseen data and limited effectiveness in long-horizon tasks, which require a greater number of successive moves for a success. This paper brings a new algorithm that uses an ensemble approach with a model-based reinforcement learning algorithm. This is efficient and offers more accurate results due to the increased planning and diversity from the

ensemble aspects of the algorithm. In order to enhance the performance of the algorithm, an ensemble technique is used where multiple models are created and trained independently. Then an aggregation strategy is employed to combine the outputs from each of these models, thus ensuring a higher quality output. This methodology has proven to be more rewarding than the current model-based reinforcement learning algorithms. This research opens up the door for future application into the finance industry, particularly with stock trading, traffic control, internet of things (IoT), energy, environment, self-driving cars, and more.

Honorable Mention

Canon Robins - Sports Analytics: Using Multiple Regression to Predict the Outcomes of NBA Games

Mathematics and Science Academy at Ocean Lakes High School

The goal of this research was to create a model to predict the outcome of NBA games. To create something unique from current literature, half-time statistics were used to create a multiple regression model predicting the total points scored in the game and the margin of victory or loss for the home team. The model was made in R using backwards stepwise regression based on AIC. It was hypothesized that multiple regressions with R^2 values above 0.65 could be created. A data set of 90 regular season games from the 2022/23 NBA season was used to create the models. The multiple regressions for total points and margin of home victory/loss had R^2 values of 0.5523 and 0.5155 respectively. These results indicate that multiple regressions can be created to predict NBA outcomes with half-time stats that are able to account for over 50% of the variance in total points and margin of victory/loss for the home team. The p-values of each variable included in the regression for predicting margin of victory/loss for the home team were analyzed to determine correlation between certain statistics and home team success. The regression models were applied to a dataset of all of the NBA playoff games from 2023. The regression models for both demonstrated R^2 values below 0.4. These results indicate that the models do not generalize to all NBA games well. The results may have also been affected by changes in NBA gameplay during the playoffs.

Abhinav Tadinada - AI-Powered Renewable Energy Forecasting

Mills E Godwin High School

Renewable energy has proven itself to be a feasible alternative to current fossil fuels and it is becoming widespread. However, one of the main drawbacks of renewable energy is the uncertainty associated with it. This is because many sources of

renewable energy are heavily influenced by climate conditions. To combat this, machine learning, a subset of artificial intelligence, can be used to predict the energy output based on the forecasted weather. This can help energy grid managers prepare for unexpected days of low energy production. Machine learning is a vast field with many different types of computational models. Each model is designed to solve a specific type of problem, and this is reflected in the structure of the model. Since the prediction of renewable energy production is a multifaceted objective, many types of models may be suited for this application. The three models tested in this study are the Seasonal Autoregressive Moving Average (SARIMA), Long Short-Term Memory (LSTM), and a custom model which is a blend between a Gradient Boosting Regressor and a Support Vector Machine. It was hypothesized that the custom model would be the most accurate because it is an effective combination of two very distinct types of machine learning models that complement each other by fixing the other's drawbacks. These models were trained and tested on data sourced from the U.S. Department of Energy and the U.S. Weather Department. The results showed that the SARIMA model had the highest accuracy of 0.885, followed by the Custom Model with an accuracy of 0.840, and the LSTM model with an accuracy of 0.763. These results can be attributed to the fact that SARIMA is better suited for recognizing seasonal changes in data, which were present in the data. All of the data is significant at a p-value of 0.01; indicating that the results are most likely due to the difference in models rather than chance.

MDH - Medicine and Health - A

First Place

Khartik Uppalati, Viraj Kamath - BSEPV2: Designing A Novel Protein with enhanced ATP Binding Capabilities Utilizing AI-Assisted Predictions of Molecular Evolution for Effective Treatment of Progressive Familial Intrahepatic Cholestasis (PFIC)

Oakton High School

Background: Progressive Familial Intrahepatic Cholestasis (PFIC) 2 is a rare, high mortality liver condition which manifests itself within 23 months of birth as a result of missense mutations within the ABCB11 gene. The Bile Salt Export Pump (BSEP) Protein which is encoded for by ABCB11 is the primary transporter responsible for the ATP-based secretion of bile salts from hepatocytes into the bile duct, being found in significantly lower quantities in those with PFIC 2. The aim of our project is developing a novel protein with greater ATP Binding activity for improved secretion of bile acids in those with PFIC 2 using in silico mutagenesis paired with an AI-Based virtual screening approach to quantify the functional impacts of mutations. Methods: A deep neural network model was trained on 1100 proteins with ideal ATP binding activity which were

annotated and scored based on Binding Affinity, Stability, and Binding Site-ATP distances. Mutagenesis was carried out in silico over 10 generations on the Walker-A and Walker-B motifs of BSEP's NBD domain using a K-means clustering algorithm to propagate mutations with positive effects, simulating natural evolution. Molecular Docking was used to compute protein stability, and Molecular Dynamics simulations were used to calculate Binding Site-ATP Distances. Virtual Screening was conducted through evaluation from the Deep Neural Network Model, utilizing computed binding properties as inputs. Top mutants were scored against BSEP, and their crystal structures were analyzed using AlphaFold. Mutants with Glycine substitutions were shown to have better binding capabilities.

Second Place

Laura Dalton - The Correlation Between Surface Temperature and Heart Disease Incidents within Ethnic Groups

Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine a correlation between average surface temperature and heart disease incidence within different ethnic groups in the United States. Data on the average temperature for the contiguous United States (CONUS) was collected from the National Oceanic and Atmospheric Administration (NOAA), and cases of death from cardiovascular disease were obtained from the Centers for Disease Control (CDC). 11 different statistical tests of correlation were run between each ethnic group's incidence of heart disease and the CONUS average temperature of the corresponding years. The groups with data from 1994-2019 were white, black or African American, American Indian or Alaska Native, Asian or Pacific Islander, and Hispanic or Latino, all of which were compared to a critical value of .369. The resulting correlation coefficients were -.245, -.232, -.233, -.242, and -.311, respectively. A critical value of .444 was used for the ethnic groups of non-Hispanic or Latino white, black or African American, American Indian or Alaska Native, and Asian or Pacific Islander with resulting correlation coefficients of -.034, -.044, -.034, -.038, respectively. There was no correlation between the variables for any single ethnic group tested. The research hypothesis that the black or African American population would have the strongest correlation between heart disease mortality and temperature was not supported by the statistical test of correlation. Overall, despite temperatures rising annually due to climate change, and the resulting environmental challenges, there is no significant correlation between heart disease mortality and surface temperature of the CONUS.

Vidya Ambati - Recasting an Anti-psychotic as a Prevention for Multiple Arthritides: Discovery of a novel receptor and mechanism of action

Individual

Gouty arthritis (GA) is an inflammatory joint disease that affects over 100 million people worldwide. It exacts tremendous disability, reduces quality of life, and increases mortality as well as billions of dollars in annual medical and economic tolls. Current therapies for GA are suboptimal and often induce serious adverse events. I analyzed 3 diverse nationwide health insurance databases of over 150 million people using Cox hazards regression and Kaplan Meier survival analyses to discover a surprising association between haloperidol, which is used to treat mental disorders, and reduced risk of GA. Using affinity probe-mass spectrometry and a biochemical pulldown assay, I identified the lysosomal protein LAMTOR1 as a novel receptor for haloperidol. Haloperidol inhibited LAMTOR1-NLRP3 aggregation and diminished inflammasome assembly. Haloperidol also inhibited subsequent inflammasome activation and secretion of the cytokine interleukin IL-1b. Together, these findings identify a novel mechanism of haloperidol's anti-inflammatory action. These studies also identify haloperidol as a potential drug repurposing candidate that could become a novel preventive therapy for GA.

Aisha Baccouche, Maryam Bilal, Soukayna Lahbabi -The Effect of Phytotherapies on Hyperglycemic Induced *C. elegans*
Governor's School @ Innovation Park

In the context to female diabetes and its association with overall health and infertility, the search for effective treatments led to the coupled use of herbal therapies with western medications. Specifically, Turmeric, Shatavari, and Gingko Biloba, are common phyto-therapeutic spices used in herbal medicines in relation to fertility and overall health. This study investigates the level of efficiency of such spices and their effect of increasing reproductive and overall health. Using wild type and induced hyperglycemic *C. elegans*, this study examines each phytotherapy's impact on overall health by examining egg count and thrash count after inducing the phyto-chemicals into the *C. elegans*' food source, cultured LB broth and *E. coli* on agar plates. Phyto-therapies were found to be preeminent, shown through an increased thrash count and an improvement in the overall health of hyperglycemic *C. elegans* when compared to wild type *C. elegans*. A Linear regression test was conducted, and results indicated statistical significance ($p < 0.05$). Moreover, Gingko Biloba has the strongest impact on increasing overall health and fertility rates in diabetic females, when compared to Shatavari and Turmeric. Comparisons between the average thrash count of wild type and hyperglycemic *C. elegans* after oral exposure to each concentration of Gingko Biloba was done using a Linear Regression, indicating statistical significance ($p < 0.05$). Findings suggest that Shatavari is an expected suitable Phyto-therapy for increasing

fertility rates in female diabetes. However, further research is necessary to support this research and determine the effects of the 0.001 and 0.0001 concentrations. Through analysis of the egg count for a concentration of 0.001 on the hyperglycemic *C. elegans*, Turmeric was found to be the most effective at 0.001 in increasing egg count with an average on 5.25 eggs across all 3 trials. In comparison to Gingko Biloba, which had an average of 4.083 and Shatavari with an average of 8.083. However additional experimentation is needed to determine the egg count of the control groups and the effect of 0.01 and 0.0001 concentrations on the egg count.

Ria Chandran -The Effect of Pharmacodynamic Constituents on KRAS Protein of Metastatic Pancreatic Cancer
Mills E Godwin High School

Examining metastatic pancreatic cancer, renowned for historical survival challenges and limited treatment options, presents a scientific endeavor poised to unveil novel insights and catalyze transformative advancements in the field. Employing deep learning, we investigate the impact of diverse pharmacodynamic constituents of gemcitabine, nab-paclitaxel, FOLFIRINOX, leucovorin calcium, and liposomal irinotecan on the KRAS protein. The absence of a control group is justified for a direct comparison of treatment effectiveness. Molecular docking simulations measure the binding affinity of these compounds to the target protein, our dependent variable. The hypothesis posits nab-paclitaxel's superior efficacy, grounded in its promising attributes. Our virtual drug discovery process integrates genomic and proteomic data, employing computational tools for virtual screening. Results, presented through descriptive statistics and inferential analysis, reveal an overall lack of statistical significance in the impact of pharmacodynamic constituents on the KRAS protein. However, specific comparisons, such as gemcitabine vs nab-paclitaxel, demonstrate significance. This research contributes critical insights into potential therapeutic strategies for metastatic pancreatic cancer, emphasizing the importance of evaluating individual compound efficacy. Findings underscore the disease's complexity, stressing the need for continued exploration to refine treatment approaches and improve patient outcomes. This research deepens our comprehension of the nuanced connections between pharmacodynamic constituents and the KRAS protein, establishing a foundation for upcoming strides in treating metastatic pancreatic cancer. To conclude, it enhances our insight into treating metastatic pancreatic cancer, emphasizing the necessity for personalized strategies. The results emphasize the complex interplay between pharmacodynamic constituents and the KRAS protein.

Tvisha Datta, Mahika Datta - Optimizing Melatonin-Based Interventions through Aromatherapy with Herbal Essential Oils for Circadian Rhythm Regulation and Thalamus Function Activity

Governor's School @ Innovation Park

Modern melatonin-based interventions are vital for regulating circadian rhythms, but they can impair key daily life functions the morning after use, such as focus, coordination, and attentiveness. This study explores optimizing melatonin-based interventions through aromatherapy using jasmine, rose, and vanilla. The goal of the experimentation was to create an intervention that addressed disrupted circadian rhythms, ensuring active thalamus functions post-use, and being effective regardless of sleeping conditions. The research involved experiments with 120 *Drosophila Melanogaster* flies being exposed to sleep-conducive and in-conducive environments while exposed to herbal essential oils via aromatherapy. Circadian rhythms were assessed through a locomotor climbing assay and a startle response assay using changes in light intensity, while thalamus functions were tested in an obstacle-filled maze. Results indicated rose oil as the most beneficial aromatherapeutic agent, promoting circadian rhythm regulation as well as enhanced thalamus functions in both sleep environments. Flies exposed to rose oil exhibited lower startle response, increased locomotor activity, and higher maze success rates. Using an ANOVA test, exposure to Rose oil resulted in an increase in motility for locomotor activity in comparison to Vanilla oil, with the p-values being not statistically significant. Thus, the use of rose essential oils offers a natural remedy for circadian rhythm imbalances without impairing thalamus function, crucial for daily activities. Through the exploration of herbal essential oils and natural treatments for sleep disorders, the potential to help develop a strong, organic, supplement in comparison to traditional pharmaceutical pills.

Aliyah Blair -The Effect of the COVID-19 Pandemic on OCD related cleaning habits
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine whether or not the Covid-19 pandemic had any effect on OCD symptoms relating to cleanliness. This study was conducted using a Google Forms Survey during December of 2023. Participants were volunteers ranging in age from 30-50 Adults, aged 30-50. The participants took a survey regarding their cleaning habits before and after the pandemic. Their survey answers were scored by calculating a sum for each participant's answers for the section on the survey focused on pre-pandemic habits and the exact same for post-pandemic habits. An average for each section of the survey was calculated using each participant's score sums. The mean score for responses to the pre-pandemic questions was 16.1 while the mean test score for post-pandemic questions was 23.1. A paired t-test, with an alpha level set at

.05, revealed a p-value of .02. This statistically significant value supported the research hypothesis, which was that adults aged 30-50 would show an increase in cleanliness frequency from the beginning of the pandemic to the end. In summation, the Covid-19 pandemic significantly affected OCD symptoms in adults aged 30-50.

Taylor Chang -The Effects of Daily Stretching
Central Virginia Governor's School for Science and Technology

This experiment aims to determine if stretching increases lower body strength. This study was conducted wherever the participants chose. Participants were split into two groups: experimental and control. The experimental group stretched 5 out of 7 times a week for a few minutes before sleeping, and the control group did nothing. The experiment took two weeks. Both groups performed data testing, consisting of three tests: pre-test, halfway, and post-test. The tests consisted of three sets of squats, testing the maximum squats in one minute. Using the percent increase from the pre-test to both the halfway and post-test; the average percent increase to the halfway test in the experimental group was 21.8%, and the control group was 2.4%. The average percent increase to the post-test was 39% for the experimental group and 3.7% for the control group. An ANOVA Multifactor test was run on my data, resulting in a p-value of 1.17×10^{-9} . A post hoc Tukey Test determined the significant differences using a Qt value of 3.74 and a Dmin value of 8.6. Significant differences existed between: Halfway (Experimental) and Halfway (Control)(mean difference of 23.057), Halfway (Experimental) and Post-test (Control)(22.596), Post-test (Experimental) and Halfway (Control) (43.941), Post-test (Experimental) and Post-test (Control)(43.480), and Halfway (Experimental) and Post-test(Experimental)(20.884) had significant differences in the percent increase of bodyweight squats. This supports my hypothesis that stretching increases lower body strength, as shown by the increased percentage of repetitions in squats.

MDH - Medicine and Health - B

First Place

Reilly Hiner -The Multigenerational Effects of Propylparaben Exposure on *Drosophila melanogaster* Reproduction

Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine whether generational exposure to propylparaben adversely affects the reproductive and developmental capabilities of *Drosophila melanogaster* and therefore, potentially humans. The *Drosophila* were divided into treatment groups by sex and exposed to a 0.01% propylparaben concentration for two generations. Each female was placed in a vial with three adult males for mating, then all four adults were removed after 48 hours. The eggs were counted under a microscope and as they emerged, the adults were inspected for malformations. Data regarding number of eggs laid and number of adults that emerged were recorded, and two single factor ANOVA tests were conducted to analyze the results. The statistical tests determined that there was a significant difference regarding the number of eggs laid, but not percent emergence. A single factor ANOVA on the eggs laid with an alpha value .05 resulted in a p-value of 1.643×10^{-3} while the percent emergence test resulted in a p-value of .27. A post hoc Tukey test on the eggs laid data showed that there was a difference between male exposure groups and the control group, where the later generations had fewer eggs. These results partially supported the research hypothesis, which was that the female exposure groups of the later generations would have lower egg counts and percent emergence than their male counterparts and the control group. In conclusion, propylparaben exposure had a significant effect on egg production but not emergence.

Second Place

Meg Garrison -The Effect of Artistic Movements on the Symptoms of Parkinson's Disease

Central Virginia Governor's School for Science and Technology

The study's purpose was to see how artistic movements affect Parkinson's Disease symptoms. Participants were required to fill out a demographic survey and consent form. After filling that out, the participants received an email with weekly instructions - draw a simple picture for 30 minutes each day. The drawings progressively increased in difficulty over the time period. At the end of the week, participants filled out a survey, asking about speech, motivation, tremor, etc. Questions came from a modified version of the Unified Parkinson's Disease Rating Scale. The total sum of their score for each week was used to find the mean scores. Then, three paired t-tests were run to test the change from week 1 to week 3, showing the overall change of the project, to see the change from week 2 to week 3, and the third test showed the change from week 1 to week 2. The p-value of the first test was .185, the second was .138, and the third .423. All were compared to an alpha value of .05. Because the alpha value was more extreme than the p-values, there was no statistically significant change in the

symptoms, suggesting that the research does not support the hypothesis that stated if patients with Parkinson's Disease participate in artistic movement for three weeks, they will show a slowing of degeneration of nerves as assessed through symptoms. However, this study is still beneficial to the knowledge of Parkinson's Disease and what can be done to help slow nerve degeneration.

Third Place

Ashley Hewitt -Studying the Similarities of Lucidity in Alzheimer's Disease and Lucid Dreaming with Galantamine

Central Virginia Governor's School for Science and Technology

The purpose of this study was to compare the effects of galantamine on Alzheimer's disease and lucid dreaming to find similarities between sudden improvements in symptoms of Alzheimer's disease, specifically terminal or paradoxical lucidity, and lucid dreaming. It aimed to study how improvement in symptoms of neurodegenerative disorders connect to the positive effects of lucid dreaming, as numerous studies have compared the two. Galantamine, used in both phenomena regularly in medical settings, was used to facilitate this change. Two-sample t-tests were run on data compiled from a study from LaBerge et. al. in 2018 and a study from Lin et. al. in 2019. The tested categories included attention/clarity, orientation/public consciousness, complexity/problem-solving, cognitive abilities/control, and mental state. The test was run by using the differences between scores measured at the initial observation (0 mg) and the final observation (8 mg) with an alpha value of .05. The research hypothesis, there being no significant difference between the change done by galantamine in the Alzheimer's and lucid dreaming groups, was supported in four out of five groups. The smallest p-value was in the orientation/public consciousness group with a p-value of 2.16E-13. The greatest p-value was in the cognitive abilities/control group with a p-value of .972. Though four out of five groups were consistent with the research hypothesis, there was a large variance and therefore lack of statistical significance between the observations of either group.

Honorable Mention

Nisah Allauddin - Effects of Sanitization and Desk Setup on Bacteria Concentration
Collegiate

Significant bacteria concentration in classrooms is the primary reason for student

sicknesses (Bright et al., 2009). The frequent sharing of equipment and densely filled classrooms has caused significant consequences in the contamination of school classrooms by increasing amounts of bacteria. It has been shown that classroom sickness is highest when surfaces in classrooms are contaminated with large amounts of bacteria (Bright et al., 2009). Measuring the concentration of bacteria is a way to determine which methods of sanitization are most effective in reducing the amount of contamination within the classroom and the number of classroom sicknesses. This research examines the effects of different methods of sanitization and social distancing on bacterial growth. While it has been shown that there are several ways to reduce the spread of germs through methods such as physical distancing (Murray et al., 2020) and wiping surfaces with sanitizing wipes (Kurgat et al., 2019), it is not clear which methods of sickness prevention are the most effective and worthwhile for schools to practice. To measure the effectiveness of social distancing and alcohol-sanitizing wipes, four classrooms were divided into control groups and treatment groups. In each classroom, there was a different target of sanitization: the first room had spaced seating and wiped desks, the second had spaced seating and unwiped desks, the third had paired seating and unwiped desks, and the fourth had paired seating and wiped desks. Puritan Medical Products swabs and Petri dishes with pre-installed agar were purchased from Carolina Biological Co. and 75 % Meishi Yu alcohol sanitizing wipes were found at the school and used for this experiment. One classroom with paired seating and one classroom with spaced seating were wiped daily using the MeisheiYu alcohol wipes while no one was in the classroom. Every seven days the same desks and doorknobs in each classroom were swabbed and the acquired samples were rubbed into petri dishes, which grew colonies in the incubator that represented the bacteria concentration for each classroom. A one-way analysis of variance showed that there was no significant difference between the classrooms that had social distancing and those that did not as well as the classrooms that had wiped desks versus those that didn't. This experiment contrasted with previous research that showed the diminishing effects of sanitization on bacteria concentration. Although the data of this experiment shows results that differ from the literature review, this research still provides insightful knowledge necessary to reduce bacteria concentration and lessen the spread of student sickness.

Honorable Mention

Holden Hughes -The Effect of Fibromyalgia Syndrome on Anxiety and Depression in Women

Central Virginia Governor's School for Science and Technology

The purpose of this study was to analyze the connection between Fibromyalgia syndrome (FMS) and anxiety and depression rates in women. This study used data from a comprehensive independent study that featured 66 participants (33 with FMS, 33 without) and included brain imaging and a complete survey. Using two separate t-tests for HAM-D and HAM-A scores, a statistically significant difference was found in both groups, between those with and without Fibromyalgia. For HAM-A scores, the group with FMS averaged 21.54 out of 56 possible points, while the control group averaged 2.18. The experimental group averaged 15.57 out of 51 possible points for HAM-D scores, while the control group averaged 1.21 points. The alpha value used for testing was 0.05, and both tests concluded that their respective samples were from different populations. The P-value for the HAM-D testing was 1.18×10^{-18} , while the P-value for the HAM-A testing was 4.1×10^{-23} . Overall, statistical significance was found within both categories with more extremity in the differences between depression intensity.

Evan Huizar - Impact of SCP2 Deficiency on Hepatic Metabolic Profiling in a Murine Model of MAFLD

Mills E Godwin High School

The homeostatic pathway between the liver and gut is now recognized and identified as one of the most vital factors in the case of metabolic disorders and dysfunctions. The sterol carrier protein 2 (Scp2) gene encode for two proteins (Scp2 and Scp-x) that are known for being key proteins in the oxidation and transportation of lipids. Recent studies have shown the possibility of Scp2 playing a role in the build-up of lipids in the liver and in the exchange between the intestines and the liver. The Scp2 global knockout mice and wild-type control mice (10 weeks old, both sexes) were fed with a Western diet (WD, Harlan, TD88137) or standard chow diet (CD) ad libitum for 16 weeks. At the end of the study, serum and liver tissues were harvested. Hepatic lipid accumulation was examined by H&E staining. Liver functional enzymes and serum biochemistry parameters were quantified using the ACE Axcel Clinical Chemistry System. The bile acid composition and levels were measured by LC-MS/MS. Total RNA was isolated from the liver tissues for metabolic gene profiling using NanoString nCounter. Data was analyzed using the ROSALIND platform. Differentially expressed genes (DEGs) identified in the study were subjected to Gene Ontology (GO) and Kyoto Encyclopedia of Genes and Genomes (KEGG) pathway analysis. This study showed that the mice with the knockout of the Scp2 gene had different gene expression when fed with WD and CD. DEGs using the GO and KEGG pathways identified that the fatty acid and lipid metabolic processes were downregulated in WD-fed Scp2 $-/-$ mice. Differences in gene expression were shown between Scp2 $-/-$ knockout and Wild

Type (WT) when mice were fed with the same WD. Comparing the Scp2 $-/-$ with the WT mice fed with WD, the GO and KEGG pathways indicated the downregulation of the fatty acid and lipid metabolic processes. Scp2 $-/-$ mice show downregulation in metabolic processes with WD. Scp2 $-/-$ that were fed with CD did not show downregulation as compared to mice fed with WD. This may suggest that the Scp2 gene plays a role in metabolic processes that may lead to a build-up of lipids in the liver which could lead to MAFLD and eventually hepatocellular carcinoma.

Diya Johar The Effect of Antibacterial Hand Soap on the Number of “Bacteria” Removed

Mills E Godwin High School

The purpose of this experiment was to determine the effect of antibacterial hand soap versus “normal” hand soap on the cleanliness of hands. The recent outbreak of Covid-19 along with the increase in the prices of good quality soaps, understanding which soaps worked best was important. In this experiment, there were three different types of hand soaps, Mrs. Meyer’s Clean Day Liquid Hand Soap (non-antibacterial), Dial Complete Antibacterial Foaming Hand Wash, and Dove Antibacterial Care and Protect Hand Wash used as the Independent Variable levels. The dependent variable was the amount of black light paint that was removed from the hands after a thorough hand wash. There were three groups and 25 trials were performed for each group. A research hypothesis was formulated that if Mrs. Meyer’s Clean Day Liquid Hand Soap was used on the hands, it would remove the same amount of black light paint if not more paint than the antibacterial hand soaps. The results were measured by using a black light flashlight and the number of “bacteria” cleaned from the hands was measured qualitatively, giving the trial a number 1 through 5. The results did support the research hypothesis. Three t-tests were performed and revealed that the data was statistically significant for one of the t-tests but was not statistically significant for the remaining levels. The results are most likely due to the lack of appropriate equipment and that the “bacteria” was just black light paint and is not a perfect way to test bacteria removal.

Tanvi Ganti -The Effect of Organophosphate Insecticides on the Growth of Heat-Stressed Planaria

Mills E Godwin High School

The purpose of this experiment was to determine the effects of organophosphate insecticides on the regeneration of heat-stressed planaria. With the majority of the world's agricultural suppliers being third world countries, the availability of PPE and safety/regulation standards is severely low. The farmers working in these nations are exposed to incredibly lethal chemicals in the form of insecticides and pesticides, many of which are banned in first world countries. This exposure, combined with prolonged exposure to UV radiation - because many of these countries fall in the line of the equator - results in severe physiological repercussions, especially to the skin. Tetrachlorvinphos, given to parasite-infected pets, and malathion, used to target mosquitoes and other garden pests, are muted forms of organophosphates and are easily attainable. However, the effects, when concentrated enough, are mirrored. Planarians were acquired and divided into two equal experimental groups, one receiving tetrachlorvinphos, and one receiving malathion. The planarians were initially exposed to 27.5 °C, the average of the daily mean high and low temperatures of the equator, 6 hrs/day, for a week to simulate equatorial conditions. They were then bisected and measured, then divided into two equal groups, and each group was subjected to 0.5mg of the pesticide in their water for two weeks. The planarians' length was then measured. It was hypothesized that the Tetrachlorvinphos would demonstrate the least growth out of the two treatments; the tetrachlorvinphos's experimental group's average growth was the smallest. A t-test was then conducted, revealing that the data was statistically significant for tetrachlorvinphos vs. malathion. Based on these results, the data supported the hypothesis, which could be attributed to tetrachlorvinphos's varying level of toxicity as a cytotoxin and diluted neurotoxin in comparison to malathion's tamer effects. For further study, the effects of these insecticides could be observed in correspondence with SPF protection.

Reyhan Haider - A Comprehensive Multiomics Approach Reveals a Novel Panel of Markers in APOE4

Freedom High School

APOE is a mediator of brain lipid metabolism and allele APOE4 is the strongest genetic risk factor for Alzheimer's disease, accounting for over 65% of patients. Two-copies of the allele increase the likelihood of developing the disease up to 15-fold. However, the effects of APOE4 on the human brain are not fully understood, limiting opportunities to develop preventative therapeutics for carriers. To gain better insights on the molecular impact of APOE4 over time, untargeted metabolomic and lipidomic profiling of cerebellum tissue samples of E3 and E4 mice was conducted at 6, 12, 18, and 21 months, amongst both males and females. Results are ongoing and will identify systemic differences through a panel of dysregulated metabolites and lipids and by

comparisons from across time points and amongst genotype and sex. Pathway enrichment will further elucidate the specific origin of these markers.

MDH - Medicine and Health - C

First Place

Priya Kumar - The Effect of different concentrations of liquid ashwagandha (*Withania somnifera*) on the heart rate of the *Daphnia magna*
Individual

Ashwagandha, or *Withania somnifera*, is an herb native to central Asia and Africa that is usually used as an adaptogen, or a substance to strengthen the body's response to external stressors. It is significant in ancient Ayurvedic systems of medicine and has been linked to several health benefits. However, not many modern studies have been conducted that study its effect on the human body, especially the cardiovascular system. With ashwagandha becoming a popular aid to treat stress and anxiety, understanding its benefits and impacts is crucial. The purpose of the experiment was to explore ashwagandha's effect on the heart rate of the *Daphnia magna*. If the heart rate decreased, then it may have a positive effect on those struggling with anxiety. The hypothesis of the experiment was, "If the *Daphnia magna* is exposed to different concentrations of liquid ashwagandha, then the heart rate of the *Daphnia magna* will decrease." Ten trials for each concentration were conducted. The average heart rate of *Daphnia magna* in spring water (control) after 10 trials was 219.2 beats/min. The average heart rate of the *Daphnia magna* for 1 drop of 1 mL of ashwagandha, 1 drop of a 1:1 dilution, 1 drop of a 1:5 ashwagandha dilution, and a 1:10 dilution were 173.6, 185.2, 198.4, and 212.8 beats/min respectively. There was a significant decrease in the heart rate of the *Daphnia magna* for the 1 drop of pure ashwagandha concentration, and the heart rate kept on increasing back to normal as the dilutions increased, which supported the hypothesis. Statistical analyses showed that the data collected from the experiment was significant, as the p-values were < 0.05 . Ashwagandha may be a prospective aid for people with stress and anxiety. Future studies should be done to explore its full benefits in reducing heart rate and helping individuals with anxiety.

Second Place

Samyukta Iyer - Assessing Inflammatory Similarities: Mice vs. Human Renal Failure Models
Mills E Godwin High School

Renal failure is a serious and increasing health issue. Based on blood reports in humans, it has been suggested that inflammation, triggered by pro-inflammatory

cytokines like IL-6 and IL-1 β , plays a significant role in renal failure. The purpose of this study was to determine if the levels of pro-inflammatory cytokines IL-6 and IL-1 β are different in renal tissue of healthy and renal failure mice. The study also aimed to see if the inflammation patterns reported by human patients correlate with those observed in the mice model. Kidney tissues from healthy (control) and cisplatin-treated mice were homogenized and assayed for protein content. Western blots were conducted, and the densities were analyzed through ImageJ. β -Actin served as a housekeeping gene to reduce errors in loading the gels. The results showed a significant increase in IL-6 and IL-1 β in the renal failure cohort, indicating that kidney damage triggers an immune response. A t-test analysis confirmed the statistical significance of the data. When compared to the control group, mice with renal failure had elevated levels of inflammatory cytokines due to the activation of cytokines in response to kidney injury, leading to inflammation. This is due to the activation of the inflammatory cascade such as the JAK-STAT pathway and inflammasome pathway, as a response to injury. Further research should evaluate the binding of IL-1Ra to the IL-1 receptor and measure protein densities of other inflammatory cytokines to better understand inflammation and its mechanisms.

Third Place

Jerry Li -The Evaluation of Anti-cancer Activity of Over-the-Counter Medication

Mills E Godwin High School

The study investigates the anti-cancer activity of over-the-counter herbal medications, specifically allicin, gingerol, and curcumin, on human head and neck squamous cell carcinoma cell lines (FaDu and SCC1) and colorectal cancer cell lines (SW480 and HCT116). The study employs the Cell Counting Kit-8 assay to measure anti-cancer activity, with cisplatin as the positive control. The results indicate that curcumin is the most effective in inhibiting cancer cell growth across all tested cell lines. Statistical analysis, including t-tests, supports the rejection of the null hypothesis, affirming the research hypothesis that the herbal medications slow down cancer cell growth. This study contributes valuable insights into the potential use of affordable herbal supplements as complementary elements in cancer treatment strategies.

Keywords: Anti-cancer activity, herbal medicine, curcumin, gingerol, allicin, cancer cell lines, Cell Counting Kit-8 assay, cisplatin, alternative cancer treatment.

Honorable Mention

Kaitlyn Hunter - Comparing Manual Therapy and Dry Needling on the Rehabilitation of Sports Related Achilles Injuries

Central Virginia Governor's School for Science and Technology

The purpose of this study was to reveal whether dry needling or manual therapy had a significant impact on the rehabilitation process of the Achilles region of endurance athletes after an overuse injury by comparing each therapeutic modality on the return of function and reduction of pain over time. This study was conducted at a STEM-related academic program for high school students and was performed online in December of 2023. The National Library of Medicine Database was used to perform background research and locate data relating to the FAAM (Foot and Ankle Ability Measure) and NPRS (Numeric Pain Rating Scale), specifically for injuries to the Achilles region. The data was measured in percentages (FAAM) and numbers between 1-10 (NPRS) and analyzed with the application of one-way ANOVA tests using an alpha-value of .05. The results from the FAAM test revealed a p-value of .004, and the NPRS results revealed a p-value of .0007. These statistically significant values, although important, did not support the research hypothesis, which stated that dry needling would be overall more effective than manual therapy in pain minimization and increase of flexibility in the Achilles region after an overuse running injury. In summary, manual therapy was found to be largely more significant in reducing pain over a period of three months as compared to the results of three months of dry needling.

Honorable Mention

Nadia Lach-Hab -The Effect of the Concentration of Polyethylene Glycol on the Zone of Inhibition of *Lactobacillus acidophilus*
Individual

The purpose of this experiment is to determine the effect of polyethylene glycol (PEG) on the zone of inhibition of *Lactobacillus acidophilus*. It was hypothesized that if *Lactobacillus acidophilus* was treated with any concentration of polyethylene glycol, then the zone of inhibition for *Lactobacillus acidophilus* growth would be larger than the control group because polyethylene glycol has bactericidal properties. The tested groups were 0% (control), 0.5%, 1%, 2%, and 5% concentration of polyethylene glycol. The experimental group treated with a 5% concentration of PEG had the largest mean zone of inhibition of 17.4 mm and the group treated with 0.5% concentration of PEG had the smallest mean zone of inhibition of 10.8 mm. The control group had growth all around. 16 trials per group were tested by treating the bacteria culture with the independent variable. An ANOVA test showed the statistical significance of this data with a p-value of 4.9×10^{-2} . T-test comparisons between the lower groups did not show statistical significance (tests done between the groups with 0.5%, 1%, and 2% concentrations). This data supported the research hypothesis. Observational data indicated light growth of the bacteria in all trials and growth of a fungus assumed to be

Candida albicans in all experimental groups after results were collected. This experiment is important in determining the effects of polyethylene glycol. It could be expanded to look at the effects polyethylene glycol, a chemical found in feminine hygiene products, has on the vaginal microbiome.

Ashley Layne -The Effects of a Specific Rest Interval on Different Levels of Physical Exertion, and How the Interval Affects Bat Speed
Southwest Virginia Governor's School

Bat speed is a critical factor for baseball and softball players on offense, and a player needs to be able to deliver their best performance when at bat. If a player is physically exerted, rest can help a player regain some of the strength and control needed when hitting in a game. Rest has previously been known to have an effect on the effectiveness, safety, and productivity in strength training. Participants in this experiment had their bat speeds measured before and after physical exertion on day one, and again on day two with periods of rest added. After each day of testing was over, a Two-Way ANOVA was used to analyze the data. After the analysis of data were completed, the results showed no significance. There was insufficient evidence to show that the rest factor ($p\text{-value} = 0.8152$) had an effect on bat speed, as well as insufficient evidence to show that the exercises ($p\text{-value} = 0.8746$) had an effect on bat speed. Therefore, there was insufficient evidence to show that the combined factors of rest and exercise had an effect on bat speed. This project could be changed by experiencing higher levels of physical exertion. Other things that can be looked at are the effects of rest on the attack angle, peak hand speed, and time to contact of players. The findings of this study showed that rest had a very minimal impact on the bat speed of the participants.

Minhyung Lee -The Causes of Spontaneous Firing of Cardiac Muscle and Effects of Ion Concentration
Blacksburg High School

Although, with my current knowledge regarding the heart and its mechanisms, we know that the heart is able to synchronize, we don't know what allows this to occur. Previous research showed that this was caused by a multitude of ions flowing through the channels between each cardiomyocyte. However, a new theory that this project is looking to prove is that the synchronization comes from the gaps between the cardiomyocytes called the perinexus. This occurs from ions all creating a similar gradient between each cell that fluctuates at a rate similar to all of its neighboring cells, making the cells all reach their action potential at the same or similar times. My initial

testing does show that there is a larger connection between the action potential and the ions traveling through the perinexus instead of the gap junctions. This was tested with different concentrations of ions with a baseline of a .5 M solution, which then was concentrated to a .7 M solution, diluted down to a .2 M solution, and then finally repeated at a .5 M solution to confirm if the variety of results was in fact coming from the differences in concentration and not an outside variable that was unaccounted for.

Jake Laneve -The Effect of Sports on a Human's Cardiovascular Health
Central Virginia Governor's School for Science and Technology

In recent times, heart health has been a rising issue with more heart attacks and heart diseases being recorded than ever before. With cardiovascular health seemingly on the decline, sports could be the much-needed solution. This study's goal is to determine which sport leads to its athletes having the best cardiovascular health. To figure this out, this study had athletes run 1000m around a track and recorded their heart rates from before and after the run to see which sport resulted in the least amount of change in heart rate. The participants were all male high school athletes from a variety of sports. After their heart rates were recorded from before and after the run, each athlete's change in heart rate into Excel to analyze the results. A single-factor ANOVA calculated whether there was any significance. Using an alpha value of .05 compared to the p-value of .610444, the data was not significant. This study's research hypothesis stating that if a variety of athletes' heart rates are all measured after participating in vigorous exercise, then endurance runners will have the lowest and least amount of change in heart rate was not supported. Overall, although the data wasn't significant it could help future researchers find ways to improve cardiovascular health.

Jordan Lucas - Comparing Different Breathing Techniques in Their Effectiveness of Lowering Elevated Heart Rate
Southwest Virginia Governor's School

People can experience elevated heart rate for a multitude of reasons. Some of the most common causes are exercise, stress, and anxiety. Breathing techniques are used frequently to lower heart rate. For any cause of elevated heart rate, breathing can serve as a grounding mechanism to calm a person down. The purpose of this work is to determine which of the three techniques will lower heart rate to normal resting heart rate the fastest. A sample of 23 participants were asked to complete three rounds of testing and complete a survey. The results were analyzed through an ANOVA test. Outside factors such as weather and sex were considered in data analysis. All of the test results yielded insignificant findings when comparing mean times of breathing techniques with

and without the previous factors. The results from this study suggest that none of the three breathing techniques tested, slow-deep breathing (SDB), pursed-lip breathing (PLB), and box breathing, is more effective than the others in lowering a person's heart rate. Though these results were not statistically significant, it was notable that the majority of participants preferred pursed-lip breathing to the other breathing techniques. These findings are consistent with those of another study examining the effects of slow, deep breathing exercises. This study further supports that breathing techniques are an effective means of slowing a person's heart rate, but the results do not suggest any new findings.

MDH - Medicine and Health - D

First Place

Berkley Milam -The Effects of Energy Drink Components on the Heart Rate of *Drosophila melanogaster*

Central Virginia Governor's School for Science and Technology

The purpose of this study was to examine relationships between energy drink consumption and the rise in cases of cardiac arrests amongst athletes of all levels, by using fruit flies as a model. The study was broken up into five test groups: a pure panax ginseng extract group (0.157g/25 vials), a pure guarana seed extract group (0.158g/25 vials), a pure taurine group (0.428g/25 vials), a group composed of a mixture of the three previously mentioned chemicals in their same concentrations, and a control group, consisting of just plain fly food. A microscope, connected to the Labscope app, was used to capture pictures and videos of the *Drosophila* heart beats for data analysis. The average number of heart beats per minute were 135 (Control), 157 (Ginseng), 157 (Guarana), and 145.5 (Combination), however, there was not enough data to find an average for the Taurine. The ANOVA test produced a P-value of .54044, (alpha .05) showing the data to be insignificant and did not support the research hypothesis which predicted that if I tested five groups of mixtures: Taurine, Guarana seed extract, Panax Ginseng extract, a chemical mixture composed of those three substances, and a control group, then the only chemical that would cause a statistically significant increase in heart rate would be the chemical mixture composed of various concentrations of the given additives; however, this experiment provided a strong foundation for further research regarding the effects of energy drinks on heart health.

Second Place

Erik Szabo -The Effect of the Food Coloring Tartrazine (FD&C Yellow #5) Added to a Fruit Fly Media Fed to the *Drosophila* (Fruit Fly) on Response to Light

Clover Hill High School

The purpose of the experiment was to determine if a diet containing the food coloring Tartrazine (Yellow #5) in amounts higher than the acceptable daily intake (ADI) would affect the vision of the *Drosophila melanogaster* fruit fly and its ability to migrate toward a fixed light source. Since both the *Drosophila* fruit fly and humans share a large amount of DNA, it is relevant to assess whether there is a correlation between amounts of Tartrazine consumed and poor eyesight, as typical diets do not provide actual monitoring of the amount of total Tartrazine consumed from various food sources. Possible negative effects could be reduced by incorporating better monitoring for humans as part of preventive health measures. The research hypothesis stated that a diet containing the food coloring Tartrazine, consumed by the *Drosophila* fruit fly, contributes to a decrease in response to light. This hypothesis was supported because there was a significant amount of decrease in the migration of the *Drosophila* towards the light source as the amount of Tartrazine was increased. The flies were kept in cultures within a drawer system that was monitored daily to maintain a temperature of $25^{\circ}\text{C} \pm 1^{\circ}\text{C}$ and relative humidity between 60-80%. After two weeks of raising, the flies fed different concentrations of Tartrazine were placed under a LED light, and the number of flies moving up to the light source was counted. The null hypothesis of no significant difference was tested using an ANOVA test. From the results gathered, the null hypothesis was rejected. The principle results from the experiment and the ANOVA test indicated that as the concentration of Tartrazine increased in the fruit flies' food medium, their eyesight was impacted, leading to a decrease in their optomotor response to light.

Third Place

Ashna Sureshkumar -The Effect of Bronchial Resistance on the Forced Expiratory Volume (FEV1)

Mills E Godwin High School

The aim of this study was to examine the effects of bronchial resistance on the forced expiratory volume (FEV1). Asthma is a chronic condition that can result in life time breathing abnormalities and mortality. In this experiment, an online spirometry simulation developed by Michał Durys was used to alter bronchial resistances. Each resistance level was used to mimic each severity of asthma and the FEV1 was recorded for each trial. A research hypothesis was proposed that increased bronchial resistance will lead to a decrease in the forced expiratory volume. Results showed that when the resistance was 800% the FEV1 was on average 0.3684 less than the 100% resistance. A t-test was conducted, and the data was found to be statistically significant for all of the comparison groups. These findings support the research hypothesis and suggest that the increased airway resistance led to a decreased airway diameter which

contributed to the low forced expiratory volume. Further research could involve testing the effects of environmental factors, such as pollution, on bronchial resistance.

Aarya Mishra -The Effect of Artificial Sweeteners on Insulin Sensitivity
Mills E Godwin High School

The purpose of this experiment was to find the effects of different artificial sweeteners on insulin sensitivity. Many sweeteners have been utilized, with a notable one being xylitol. Its usage has surged in various products, with gum notably experiencing a significant increase in the past few years. Another standing sweetener in the food industry is aspartame, being in many sodas and foods. These artificial sweeteners are used as an alternative to the sugar which causes diabetes. Famished drosophilae were fed either aspartame, xylitol, or sucralose and after twelve hours, the insulin sensitivity was measured with a spectrophotometer. The control for this experiment was no artificial sweetener. It was hypothesized that if aspartame was fed to drosophila, then the insulin sensitivity would increase. The results revealed that on average, sucralose was the best artificial sweetener, leading to the least amount of insulin sensitivity, and aspartame had the most negative effect on insulin sensitivity. A t-test was performed on the collected data with all the tests being proven significant, and it was found that the results did support the research hypothesis. It is believed that the results are due to the many implications of consuming aspartame including depression, heart disease, cancer, and diabetes. This research could lead to further studies that investigate artificial sweeteners and different diseases, such as cancer.

Anchal Patel -The Effect of Applying Neosporin vs. Turmeric to Bisected Planaria on the Number of Fully Regenerated Planaria, Over Time
Clover Hill High School

The purpose of this experiment was to determine which medical treatment would yield the greatest number of fully regenerated planaria. Neosporin and turmeric were both considered medically beneficial and effective for humans. Since planaria and humans were discovered to consist of similarities related to the body, Neosporin and turmeric were individually tested on planaria to observe if any of the medications were effective on planaria or not. The hypothesis was that if planaria were treated with each medication of turmeric and Neosporin, the exposure to turmeric rather than Neosporin would enhance the number of fully regenerated planaria. Eighteen petri dishes were laid out on the counter in groups of six. The three levels of independent variables were control, turmeric, and Neosporin. Fresh room-temperature water was poured into all petri dishes and replaced as needed. The planaria were bisected and placed into three

groups, each consisting of 30 heads and 30 tails. A micropipettor was used to apply 10 microliters of Neosporin and turmeric to each of the 30 heads and 30 tails in the turmeric and Neosporin groups. Each group was checked for signs of regeneration at the end of each week, for 3 weeks. The mean number of fully regenerated planaria for each level of independent variable was recorded at the conclusion of 3 weeks. The average number of fully regenerated planaria was 0.7 for the Neosporin group, and 1.0 for the turmeric and control groups. The turmeric and control groups equally displayed the highest number of fully regenerated planaria. Planaria treated with turmeric showed the greatest number of fully regenerated planaria compared to Neosporin, so the experimental hypothesis was supported. The null hypothesis of no significant difference was tested using a Chi-Square test, and the null hypothesis was rejected. However, treatment with either ointment would not be necessary since the control and turmeric groups had the same outcome.

Kaavya Shah -The Prevalence of Thyroid Disease in Ultrasound Screenings Across Various Regions in the United States
Mills E Godwin High School

Thyroid diseases worldwide comprise a large spectrum ranging from Hypothyroidism, an underactive thyroid, to potential cancerous growths that require intensive care and treatment. Understanding their underlying causes and having accessible treatment options is crucial for improved outcomes. The prevalence of thyroid disease can be influenced by regional factors, such as environmental, nutritional patterns, and genetic predispositions, underlining the importance of considering geographical variations in health discussions. This study observed the prevalence of thyroid disease in ultrasound screenings across regions in the United States and its purpose was to investigate whether regional variations influence the presence of thyroid disease. After obtaining approval from the company from which the cases were selected, a total of 1,250 cases spread across 5 regions were chosen and reviewed by board-certified radiologists. Data were compiled into tables and analyzed using chi-square tests. With no control group, the research hypothesis suggested the highest prevalence in the West. The results of the study showed that 136 (54.4%) cases in the Southwest, 149 (59.6%) in the West, and 128 (51.2%) in the Midwest showed signs of thyroid disease. Furthermore, it revealed that only 93 (37.2%) cases in the Southeast and 74 (29.6%) in the Northeast contained a form of thyroid disease, supporting the research hypothesis. Upon further analysis, both the South and Northeastern regions appeared to be non-significant and accepted the null hypothesis. However, the Midwest, Southwest, and West regions all showed significance. Possible explanations for errors found in this study could include the sample size being too small and the use of a cluster sampling method.

Samantha McKenney – The Effect of Pacifier Usage on Speech Development
Chesapeake Bay Governor's School

Effective communication is crucial for navigating life, and speech-sound development plays a pivotal role in establishing communication skills. Communication disorders, affecting 5-10% of all children in the United States, encompass impairments in speech, language, and hearing. Speech pathology, a field focused on communication science and disorders, is instrumental in diagnosing and treating these disorders. Previous research has linked non-nutritive sucking habits, such as pacifier usage, to speech development delays. Pacifier usage has been associated with altered tongue and teeth positioning, leading to malocclusion, and diminished auditory input, potentially affecting speech comprehension and pronunciation. This study explores the impact of the duration of pacifier usage on speech development in children ages six and seven. Speech screenings were conducted with first and second graders at elementary schools to assess the number of phonemes (speech sounds) they could accurately say. Parents were surveyed regarding pacifier usage history, and participants were assigned numbers for anonymity. The screenings involved presenting pictures targeting specific phonemes, with students pronouncing phoneme displayed on the page. The number of phoneme pronunciation errors were tallied for analysis. Results indicate that 85% of six-year-olds and 60% of seven-year-olds in the sample used pacifiers. The average number of phoneme errors increases with the duration of pacifier usage, with the highest average (9.3 errors) observed in children using pacifiers for over 36 months. A linear regression test resulted in a highly significant P-Value less than 0.01, suggesting a significant correlation between longer pacifier usage and increased phoneme errors.

Maytal Zasler - Figure Skating Training and Balance: A Quantitative and Comparative Analysis
Collegiate

The positive effects of physical exercise on brain neuroplasticity have been recognized for many years. Figure skating training (FST) is correlated with beneficial changes in cerebral components that control motor skills and balance development. The areas of the brain affected by the repetitive motor skills and balance training required for figure skating, such as the cerebellum as well as visual and vestibular cortices, have also been linked with improvements in higher-level coordination and balance function. The objective of this study was to examine the effects of FST on objectively measured, higher-level balance ability in adolescent females compared with a control group of adolescent females who did not participate in regular FST. The Balance Error Scoring

System (BESS) was utilized as an objective and portable static stability assessment tool for this study. The BESS requires both floor and foam pad examinations. Twenty female figure skaters and twenty female non-figure skaters were tested with the BESS during the study period. BESS scores were collected for both floor and foam pad performance and statistically analyzed. Study results from the BESS assessments indicated that regular FST was positively associated with better performance on measures of balance. These results have significant implications for understanding the underlying consequences associated with specific types of regular exercise training on brain neuroplasticity. The figure skaters were the Independent Variable and the non-figure skater sample acted as the Control. The Dependent Variable observed was the corresponding BESS score of each participant. The results of this study suggest that prolonged and consistent figure skating training (2+ years, 4+ hours per week) improves balance, with the figure skaters demonstrating an average of 10.8 errors and the non-figure skaters demonstrating an average of 14.85 errors. ($t(19) = 3.59$, $p = .00047$, Cohen's $d = 0.99$).

MCB - Microbiology and Cell Biology - A

First Place

Sadie Hengst -The Effect of Different Natural Antibacterial Agents on Escherichia coli
Individual

Concentrated animal feeding operations (CAFOs), commonly known as factory farms, are a large contributor to the spread of antimicrobial resistance (AMR) due to the unsanitary, overcrowded conditions livestock are kept in and the excessive use of antibiotics in their feed to prevent disease. The purpose of this study was to find the natural antibacterial agent that was the most effective against Escherichia coli, a species of pathogenic bacteria commonly found in chicken intestines that has evolved multiple antibiotic-resistant strains. The antibacterial agents tested were garlic extract, oregano essential oil (EO), cinnamon EO, and cumin EO, while the control was no antibacterial agent. It was hypothesized that the garlic extract would be most effective due to the consistently high antimicrobial activity of allicin, a molecule prominent in crushed garlic. The experiment was conducted by inoculating Petri dishes with E. coli bacteria, then treating each colony with a different antibacterial agent, and measuring the diameter of the zones of inhibition after 48 hours of incubation. The results showed that the oregano EO and cinnamon EO were most effective against E. coli, with the same mean zone of inhibition of 3.5 cm. Conversely, the control had 0 inhibition. The data collected suggests that while all four antibacterial agents were effective against E. coli, the oregano EO and cinnamon EO had the highest and most consistent levels of inhibition. This provides further insight into the best alternatives to antibiotics for factory farms to add to animal feed.

Second Place

Ruby Goff - Cytotoxic Effect of Varying Doses of Allura Red AC, Brilliant Blue FCF, and Sunset Yellow FCF on *Allium cepa* L. Cells
Collegiate

Azo dyes are a large class of synthetic dyes whose molecules contain two adjacent nitrogen atoms between carbon atoms. They are the most employed artificial colorants, being utilized in diverse applications in the commercial industry. Their usage has been researched, as it has been shown many of their degradation products release very high levels of acute and chronic toxicity and carcinogenicity (Bafana et al., 2011). Examining the mitotic index of cells is a way of determining the cytotoxic effects of azo dyes, as the mitotic index provides a measure of the capacity of cells to divide and of the rate of cell division at a given time, which is an essential process for the proliferation of cells. The present study examined the association between varying doses of azo dyes Allura Red AC (FD&C Red No. 40), Brilliant Blue FCF (FD&C Blue No. 1), and Sunset Yellow FCF (FD&C No. 6) and the mitotic index of *Allium cepa* L. cells. Twelve onions were sprouted in ideal conditions for approximately ten days. A total of nine solution treatments were prepared at 1/2, 1, and 2 times the Acceptable Daily Intake (ADI) of the three azo dyes. The roots of the sprouted onions were subsequently exposed to their respective solution for 24 hours. Following the exposure period, the cells from the root tip were fixated in Clarke's Solution and hydrolyzed in 1.0M HCl. Then, the cells were prepared for microscopy and stained with 1% acetocarmine. Under a light microscope, the number of cells in a phase of mitosis and the number of cells in interphase were counted, from which the mitotic index was determined. Chi-squared tests for the association between each azo dye colorant and the mitotic index of the onion cells displayed no statistically significant results. In addition, Chi-squared tests showed no statistically significant relationship for the association between half of the ADI and the actual ADI doses of each dye on the mitotic index of onion cells. However, a Chi-squared test for the association between two times the established ADI of all three azo dyes and the mitotic index of the onion cells produced statistically significant results. This data coincides with previous academic studies that provide evidence that prolonged exposure and excessive ingestion of azo dyes can generate cytotoxic effects. Moreover, this research helps confirm the established Acceptable Daily Intakes of the examined azo dyes. Overall, this study emphasizes the importance of regulating azo dyes to protect the cell health of all exposed to azo dyes.

Third Place

Anna Carter – Application of CRISPR Gene Editing in a Classroom Setting

Central Virginia Governor's School for Science and Technology

The purpose of this study was to test the application and efficacy of CRISPR gene editing in a classroom setting. This study was conducted at a high school laboratory using a Bio-Rad Out of the Blue CRISPR gene editing kit. The time frame for the project was during October and November of 2023. Four groups of agar plates were tested, half being IX with Arabinose and the other IX without. An inoculating loop was used to carefully disperse *Escherichia coli* onto each plate; these served as streak plates. Then a new inoculating loop was used to introduce the *E. coli* to the different solutions: plzDonor for Groups A and C and plzDonorGuide for Groups B and D. The *E. coli* and corresponding solution mixture were then placed into IX with Arabinose and IX without Arabinose agar plates. After finishing the procedure and incubating the plates, the means of the edited groups were 278.8 CFU blue for Group A, 0 CFU for Group B, 339.2 CFU blue for Group C, and 38.6 CFU white for Group D. The white coloring indicated successful gene editing, as the color was altered from blue to white. These results partially supported and surpassed the research hypothesis with 100% success rate instead of the 50% that was hypothesized. In conclusion, CRISPR gene editing is effective in a classroom setting and can be utilized to help discover new applications in biological research.

Honorable Mention

Megan Bell -The Effect of Temperature on Dye Dispersion in Agar Plates

Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if temperature had an impact on dye dispersion levels in agar plates. The research hypothesis was that if agar plates with dye-filled wells were incubated at different temperatures, then the plate at 22°C would create the largest dye dispersion. Three different temperature levels were used for this experiment: 8°C, 22°C, 32°C. Seven samples per group were in the incubators for 3 hours, this made a total of 21 trials. The dispersion length of the dye was calculated by measuring the diameter (cm) of the dispersion. A one-way ANOVA test was used to determine if the groups were significant; the alpha value used was .05 and the p-value generated was 3.39×10^{-12} . A post-hoc Tukey test determined which groups held significance, with a Q_t value of 3.61 and a D_{min} value of .054. The difference was shown in all of the groups, this partially supported the research hypothesis, that the 22°C group would have significance, but the 32°C had the most significance. The result of this study suggests that dispersions within agar create larger diameters in warm environments

Honorable Mention

Dylan Borek, Josh Rizer, Izidor Yatsevich - Effects of Ocean Acidification and UV Radiation on *Spirulina major*
Governor's School @ Innovation Park

Climate Change is a phenomenon with many adverse effects on all sectors of the environment. Two significant effects of Climate Change are ocean acidification and increased ultraviolet (UV) radiation. This study was designed to test the effects of these factors on the cyanobacteria *Spirulina major*, an important marine primary producer. It was hypothesized that if *Spirulina major* populations are exposed to these two factors, their photosynthetic rate will decrease due to radiation's harmful effects and decreased pH. To test the hypothesis, three trials of four experimental groups were cultured: one control (8.1 pH), one subjected to decreased pH (7.9) and UV exposure, and two being subjected to one of the factors each. Resulting absorbance values, O₂ and CO₂ concentrations, and population viability were recorded for each sample as indicators of photosynthetic health. An ANOVA test of variance was collected to determine the significance of the difference between groups, which revealed that any differences between the control group and experimental groups were not statistically significant, indicating that marine primary producers do not experience direct detrimental effects through Climate Change. While not aligned with the initial hypothesis, the results of this research are important to understanding the impact of global change on marine environments, because while primary producers may not be directly harmed, the resulting overpopulation of these species often results in a net negative effect for the environment, as seen in the algae bloom phenomenon. Further research is required to place these findings in the context of the broader ecosystem.

Honorable Mention

Ava Gray Fontana -The Effects of Different Brands of Sunscreen on *Lytechinus variegatus* Fertilization
Central Virginia Governor's School for Science and Technology

The purpose of this study was to identify how sunscreen affected fertilization rates in sea urchins to demonstrate chemicals in typical sunscreens harm reproduction and fertilization in aquatic organisms. The model organism, *Lytechinus variegatus* was used for ease of gamete retrieval. To collect the gametes potassium chloride was injected through the mouth tissue to induce muscle contractions. Once gametes were expelled, the eggs went through a centrifuge machine twice to conduct an egg wash and the sperm was then diluted into a mixture of saltwater and their respective sunscreen (Sun Bum, Banana Boat). The eggs and diluted sperm mixture were pipetted into petri dishes to fertilize for 24 hours. After the allotted time the average fertilization percentage for

SunBum lotion was 21%, Banana Boat Sunscreen lotion was 23%, and the control group was 67% fertilized. The statistical test ran in this study was a one-way ANOVA test that gave a p-value of 6.5×10^{-9} , smaller than the alpha value of .05. A Post Hoc Tukey test was also conducted with a Dmin value of .072 which indicated -0.45 was significant from -0.431. My research hypothesis, if sea urchin gametes were exposed to solutions of sunscreen, those in SunBum would have the worst percentage of fertilization as compared to Banana Boat and the control with no sunscreen. Further analysis is ongoing, but these results conclude sunscreen is detrimental to aquatic life by harming the organism itself and its phases of development.

Henry Guo -The Effect of Divalent Ions on the Viability of *E. coli*
Mills E Godwin High School

The purpose of the experiment was to evaluate the effectiveness of using divalent ions as an option against antibiotic-resistant bacteria. Strains of bacteria mutate and become resistant to the limited antibacterial drugs available and pose an alarming issue in the treatment of infections due to resistance. With a reported five million antibiotic-resistant bacteria-related deaths in 2019 by the CDC, the worldwide issue of “superbugs” will continue to evolve. The implication for society, if this issue is not resolved, would be mass suffering and death from illnesses that would have been curable if not for the spread of resistant bacteria through antibiotic abuse. The hypothesis of the experiment was that if CuSO_4 was the divalent ion used to kill *E. coli*, then it would be the most effective. Since copper has been used to create cookware that has antimicrobial properties, CuSO_4 should be the most effective against bacteria. The control was a negative control, which allowed a comparison against data without added divalent cation ions. The experiments showed that the control, on average, contained the most CFUs. MgCl_2 had a higher average CFU than CaCl_2 and CuCO_4 . CaCl_2 had the lowest average CFU count, which meant that the results did not support the hypothesis. The exponential nature of bacteria also contributed to a varied data set since a slight offset in starting conditions will leave a large offset in the results. This experiment demonstrated that CaCl_2 and CuSO_4 are both effective at eliminating bacteria.

Hanke Helen - The Effect of Different Types of Oral Care Rinses on the Growth of *Staphylococcus epidermidis*
Individual

The purpose of this experiment was to study the effect of diverse types of oral care rinses on the growth of *Staphylococcus epidermidis* and in the prevention of hospital acquired pneumonia. The hypothesis stated that if hydrogen peroxide was used, then

the *Staphylococcus epidermidis* would have the least growth because it has shown in studies to have a similar effect as oral rinses with Chlorhexidine gluconate which is the best ingredient in preventing hospital acquired pneumonia infections and killing *Staphylococcus epidermidis*. The hypothesis was supported by the data because hydrogen peroxide killed all the bacteria, averaging a zone of inhibition of 4.5 cm. Crest advanced protection also killed most of the bacteria with an average zone of inhibition of 4.3 cm. Saltwater rinse had an average zone of inhibition of 2.3 cm and the distilled water, control, had an average zone of 0 cm. An ANOVA test was done to determine if a statistically significant difference existed among the means for the groups. The calculated p-value was 2.79×10^{-49} which was smaller than the critical value of 0.05, meaning the data was statistically significant. This means the null hypothesis: if *Staphylococcus epidermidis* is treated with different oral care rinses then no difference will occur in the zone of inhibition, is not accepted.

Nadia Hassen -The Effects of Natural Ingredients Found Commonly in Natural Toothpaste on the Growth of *Corynebacterium*
Washington Liberty High School

This experiment was conducted to test the effects of natural ingredients found commonly in natural toothpaste on the growth of *Corynebacterium*. It was hypothesized that if natural ingredients are tested to see which one has the highest zone of inhibition, then the zone of inhibition will be the highest if xylitol is used and applied, because xylitol has antibacterial properties enabling it to kill high amounts of *Corynebacterium* and it also has an antimicrobial effect. *Corynebacterium* is a type of mouth bacteria that is commonly found in the mouth, specifically cavities and is seen to come together to make larger structures known as dental plaque. In addition, *Corynebacterium* is seen to cause little harm to humans. The experimental groups that were tested in this experiment were calcium, coconut oil, cranberry extract, and xylitol. Out of all the experimental trials conducted, each group had 16 trials per each experimental group except the control group which only had four trials. All the trials had bacteria swabbed on the petri dishes and after being treated with the independent variable, they were measured for the zone of inhibition. An ANOVA test was also conducted after this experiment that showed a p-value of 0.387 which was greater than the critical value of 0.05. Since the p-value was greater than the critical value, the null hypothesis couldn't be rejected meaning that there was no significant difference between the experimental groups. This was not the expected results as it was predicted that there would be significant difference between these experimental groups, as xylitol was hypothesized to have the highest zone of inhibition compared to other experimental groups like calcium. Due to the fact that the ANOVA test was not significant and that there was no difference between the experimental groups, it meant that the results were inconclusive. In the

end, this experiment is important in helping natural toothpaste users look out for specific ingredients in their toothpaste that will help with bacterial prevention.

Beckett Normington -The Effect of Different Topical Anti-Acne Treatments on the Zones of Inhibition of *Staphylococcus epidermidis*

Individual

This experiment quantified the inhibition of *Staphylococcus epidermidis* by different topical anti-acne treatments. The hypothesis stated that the group treated with filter paper discs containing 5% benzoyl peroxide topical wash would have the greatest mean zone of inhibition. Sterilized filter paper discs were treated with 5% benzoyl peroxide topical wash, salicylic acid 2% anhydrous solution, 100% tea tree oil, and distilled water. Petri dishes were prepared and inoculated 48 hours later. The discs were applied to the dishes, and the plates were incubated for 48 hours. The mean diameter for each quadrant of each dish was recorded from three directions through the center of each disc and compiled into a data table. The summative data table includes the mean diameter of the measurements for each group. The standard deviations of each group were calculated and recorded, along with an ANOVA test of all groups and a t-test between two groups. The data are statistically significant and do not support the hypothesis. The group treated with 100% tea tree oil had a mean zone of inhibition of 4.83 millimeters, followed by the 5% benzoyl peroxide topical wash group with a zone of inhibition of 2.72 millimeters, the 2% salicylic acid anhydrous solution with a zone of inhibition of 0.26 millimeters, and finally the distilled water control group at 0 millimeters. Thus, 100% tea tree oil had the greatest impact on bacterial growth. The experiment could be improved by getting forms of the treatments without additives to reduce error source

MCB - Microbiology and Cell Biology – B

First Place

Bhoomika Kaur - Investigating the Therapeutic Potential of Natural Products on Advanced Glycation End Product (AGE) Formation and Function in MyC-CaP Prostate Cancer Cells

Mills E Godwin High School

Purpose: The accumulation of advanced glycation end products (AGEs) has been implicated in numerous geriatric diseases, notably cancer. However, no potent therapeutic agent that targets both AGE formation and treatment exists. Therefore, the objective of this experiment was to identify a natural product (NP) exhibiting efficacy in

inhibiting and mitigating AGE formation and function, respectively. Methods: A fluorescence-based assay was utilized to investigate the inhibitory effects of NPs by quantifying AGE formation in the presence of the following treatment solutions: the negative control ethanol (EtOH); turmeric; Algae-Fraction 1 (AF-1); and Aminoguanidine (AG), the positive control. Additionally, a migration assay was performed to identify the NP with greatest potency in treating pre-formed AGEs by quantifying the amount of MyC-CaP cell migration across a porous membrane in response to the subsequent treatment solutions: AGEs, the negative control; AGEs & AF-1; and AGEs & AG, the positive control. It was hypothesized that the turmeric and AGEs & AG solutions would have the greatest inhibitory and alleviatory effects, respectively. Results: The results revealed that the novel compound AF-1 was the most effective in inhibiting and treating AGEs. T-tests were conducted and revealed that the data was both statistically significant and insignificant. The results did not support the research hypothesis. Conclusion: It is believed that the results occurred due to algal derivatives' richness in antioxidants and phenolic compounds, which created an unfavorable environment for AGEs and interfered with AGE-RAGE axis activation in cancer-associated fibroblasts (CAFs). Further studies should evaluate the physiological effects of AF-1 on cancer-inflicted murine models.

Second Place

Emma Krzyzanowski - Bacteria's Antibiotic Resistance to Tetracycline
Hampton Roads Academy

Environmental DNA (eDNA) has helped scientists learn about the detrimental effects antibiotic-resistant bacteria can have on public health. This growing concern has become one of the most significant public health issues, causing a need for greater insight. As bacteria's antibiotic resistance rapidly grows, bacterial hotspots have become an area of interest in learning more about antibiotic resistance. By studying the bacteria hotspots in my local community, I can help scientists understand how resistance spreads in the environment. As there are limitations in the ability to survey eDNA widely, this project aims to isolate, culture, and examine bacteria's sensitivity to the antibiotic tetracycline in soil samples within York County and Newport News, Virginia. Five soil samples were collected, diluted, and grown in MacConkey agar plates with different levels of tetracycline, a widely used antibiotic. After the incubation period, it was discovered that three of the five soil samples contained bacteria resistant to tetracycline. PCR and gel electrophoresis also confirmed the presence of tetB and tetM, antibiotic-resistant genes. All positive soil samples and selected colonies were chosen to undergo sequencing. A Kirby-Bauer test was performed to see the bacteria's sensitivity to Amoxicillin, Erythromycin, and Ciprofloxacin. No differences were found

between the control and experimental plates, suggesting tetracycline-resistant bacteria were sensitive to the antibiotics tested.

Third Place

Madeline Levorson - Discovery of Medically Important Lytic Bacteriophage in the Environment

Thomas Jefferson High School for Science and Technology

Antibiotic resistance is increasing and there may be no antibiotics that work against bacterial infections in the near future. It is estimated that over three million antibiotic-resistant infections occur each year in the United States and nearly 40,000 people die each year due to antibiotic resistant infections. Lytic bacteriophages are viruses that lyse and kill bacteria. These bacteriophages are host-specific and can only infect their specific bacteria. If these bacteriophages can be found, isolated, and characterized, they can be used to treat infections, which is very important as they are alternatives to traditional antibiotics. Four environmental samples (compost, pond water, stream water, and kimchi liquid) were collected to attempt to find bacteriophages against *Escherichia coli* (E. coli) B, E. coli K12, and *Pseudomonas putida*. Two novel E. coli B lytic bacteriophages were discovered and named Ozzy and Slash. After discovery of Ozzy and Slash, a novel spectrophotometric Rapid Phage Screening Protocol (RPSP) was validated. Different concentrations of Ozzy and Slash were used and compared to two known bacteriophages, T2 and T4 against E. coli. These phages displayed a time-dependent decrease in optical density (OD) absorbance. Not only were two novel environmental E. coli B bacteriophages, Ozzy and Slash, discovered but the novel RPSP was validated with these two-novel bacteriophage. This screening protocol can be widely used for the discovery of novel lytic environmental bacteriophages and will shorten the time from the discovery of novel bacteriophages to implementation in the treatment of antibiotic-resistant bacterial infection.

Honorable Mention

Deepanshi Kumar - Mitigating the Spread of *Cryptococcus neoformans* Infections: The Effect of Green Tea Consumption on *Paramecium aurelia* Feeding Rate

Individual

Cryptococcus neoformans is a unicellular yeast found in trees and soil that can cause deadly infections in immunocompromised humans. However, this fungus can also be ingested and killed by *Paramecia aurelia*, presenting a possible method for mitigating the spread of such infections. The purpose of the study was to understand if green tea extract can increase metabolic activity in P. aurelia, resulting in a faster feeding rate on

yeast. Green tea contains polyphenolic catechins which are known to enhance intracellular and enzyme activity. Specifically, consumption of Epigallocatechin gallate (EGCG) in organisms can result in increased metabolites. In this experiment, *P. aurelia* were exposed to solutions of 10% and 20% green tea concentration on a slide. Then, the *P. aurelia* were fed stained yeast and their behavior was observed under a microscope. The feeding rate was recorded by observing the number of yeast particles consumed and calculating the rate in particles per second. The results rejected the null hypothesis that green tea had no impact on *P. aurelia* feeding rate as both the levels with 10% and 20% green tea had higher mean feeding rates than the control of 0% green tea concentration. An ANOVA test confirmed the statistical significance of all three levels and a T-test confirmed the significant difference between the 10% and 20% levels, although the feeding rates were relatively close. The 20% level had a feeding rate of .84 particles/second, while the control had a feeding rate of .34 particles/second. This result is likely due to the metabolic potential and capabilities within green tea's polyphenolic catechins. Not only does this research help develop a better understanding of the protist-fungal interaction between *P. aurelia* and *C. neoformans*, but it also has a significant global health impact. This research is incredibly important in reducing the spread of *C. neoformans* infections through the feeding behaviors of *P. aurelia* on yeasts.

Honorable Mention

Reagan Labert, Iana Niknezhad - Development of Novel RNA Therapeutics for Female Infertility

Mathematics and Science Academy at Ocean Lakes High School

mRNA therapeutics have gained increasing amounts of attention in recent years as promising treatment methods. However, usage of mRNA therapeutics in treating other health-related issues, such as women's infertility, has limited research, providing limited scopes in this treatment option. This study aims to investigate the effect of RNA nucleotide base modifications on the ability of mRNA to be translated within a human embryonic kidney (HEK-293) cell, thereby exploring the potential usage of mRNA therapeutics to treat female infertility. By transfecting mRNA with modified nucleotide bases into HEK- 293 cells, it is hypothesized that the amount of mRNA translation will vary based on the modified nucleotide utilized. Furthermore, in order to increase the scope of transferability of the research to reproductive cells, an optimal method for cultivating oocytes was developed in parallel to mRNA translation studies. It was hypothesized that this procedure of cultivating and injecting oocytes would be improved by clearing the follicle-handling media, where oocytes were cultivated. For this research, mRNA modifications inosine, N1-Methyladenosine, N6 Methyladenosine, pseudouridine, N1-Methylpseudouridine, and 2-Thiouridine were tested, each on their

own mRNA construct. An unmodified mRNA control was also utilized. Due to its ability to produce a red fluorescence when properly translated, miRFP670 DNA template was used in combination with each nucleotide base modification during in vitro transcription—the process of transcribing mRNA outside an organism. The resulting modified miRFP670 RNA constructs were subsequently purified and transfected into HEK-293 cells. Protein expression was analyzed through observation of fluorescence, and an optimal protocol for cultivating oocytes was tested using a measure of protein abundance.

Honorable Mention

Julia Neidert -The Effect of Amount of Time Exposed to Light on the Light Output of Bioluminescent Photosynthetic Dinoflagellates
Clover Hill High School

This experiment was conducted to determine the light output of bioluminescent *Pyrocystis fusiformis* dinoflagellates when they were exposed to different light cycles. These dinoflagellates are exposed to about 12 hours of light (L) and 12 hours of darkness (D) each day in the wild, so that was used as the control. The alternate cycles were 24 hours L and 0 D, 18 L/6 D, 6 L/18 D, and 0 L/24 D. The dinoflagellates were placed underneath 5 buckets, one for each light cycle, where the only light they could be exposed to was the lightbulb inside the bucket. Their circadian rhythms were regulated at a 12 L/12 D cycle for three days. The light output of the dinoflagellates was then measured with a lumen meter. For the next three days, the appropriate alternate light cycles were used in four of the buckets, while the fifth remained on the control cycle. The light output was measured again after the next three days. The experimental hypothesis stated that if *Pyrocystis fusiformis* dinoflagellates were exposed to the alternate light cycles, the 18 L/6 D cycle would result in the highest luminosity because the dinoflagellates would be exposed to more light, but they would still have enough darkness to reset the circadian clock they use for bioluminescence. The dinoflagellates in the 18 L/6 D cycle produced the most lumens, with a mean of 0.048. In order of brightest to dimmest, this was followed by 12 L/12 D, 6 L/18 D, 0 L/24 D, and finally, 24 L/0 D. They had means of 0.042, 0.031, 0.027, and 0.018, respectively. The experimental hypothesis was supported, and the null hypothesis was rejected. A one-way ANOVA test was used to determine significance.

Nicola Beaumont – The Use of Chlorella as a Coagulant/Flocculant to Remove Polyethylene Microplastics from Wastewater
Individual

Microplastics (MP), formed by plastic degradation and manufacturing, are found throughout the water system, threatening the health of aquatic species and humans as they enter the food chain. While wastewater treatment removes most organic material, additional methods are needed to fully remediate MPs. Chemical coagulation and flocculation processes are an option but can have adverse impacts on the environment. Algae, whose cell walls have a variety of functional groups that can act as binding sites, could be an eco-friendlier coagulant/flocculant. Indeed, existing research has found that *Chlorella* is an effective coagulant/flocculant for polyethylene (PE) microplastic samples with diameters averaging around one micron; however, PE particle sizes have a wide range in practice. Accordingly, this study's purpose was to see if *Chlorella* would be effective at remediating larger sized PE particles. To obtain the coagulant/flocculant, *Chlorella* was grown in a photobioreactor; solutions were then centrifuged and algal mass dried. Next, varying concentrations of *Chlorella* were added to distilled water and mixed with PE microspheres ranging from 10 μm to 710 μm in size. The solutions were placed into separating funnels, allowing floc sedimentation; the supernatant was removed and filtered to isolate the PE particles which remained in solution. The weight of filtered, unremediated PE particles was compared to the weight of initial PE particles to assess the effectiveness of *Chlorella* PE remediation. While this study found that *Chlorella* did remediate larger sized PE particles, the remediation was small, with maximum removal of only 16% for particles 10-150 μm and 4% for particles 600-710 μm . An ANOVA analysis found that differences in removal shares between smaller and larger sized PE particles were statistically significant. These results are useful in better identifying what size PE particles *Chlorella* could best remediate.

Saanvi Jain -The Effect of Antibacterial Properties of Natural Substances on K12 *Escherichia coli*
Mills E Godwin High School

The purpose of this experiment was to assess the antibacterial properties of natural substances against K12 *E. coli*. Recently, as regular antibiotics faced resistance, natural substances have been tested for their antibacterial properties. *E. coli*'s susceptibility to apple cider vinegar, honey, ginger, turmeric, and water (control) was tested using a disk diffusion assay on agar plates. The zone of inhibition was measured after 24 and 48 hours and recorded. It was hypothesized that if the turmeric-infused disk were used, it would result in the largest inhibitory zone. The apple cider inhibited the most, honey's inhibition was irregular, and turmeric and ginger didn't show any inhibition. A t-test conducted on the data revealed that the data for apple cider vinegar was statistically significant. The same t-test showed that the data for ginger, turmeric, and honey was not statistically significant. The results did not support the research hypothesis. The results suggest that turmeric and ginger-infused disks may not be as effective against

K12 E. coli as previously thought. This could be due to their solubility and concentration. Using natural substances instead of plant extracts may also have played a role. However, the acetic acid in vinegar and the sugar concentrations in honey caused susceptibility in the bacteria. Further research should implement plant extracts and other natural substances on K12 E. coli and other bacteria.

Lydia Joh -The Effect of Concentration of Sugar in a Sugar-Water Solution in a Liquid Medium on the Resultant Optical Density, After Inoculating the Medium with E. coli
Clover Hill High School

The purpose of the experiment was to determine the effect of glucose concentrations on the growth of Escherichia coli. Knowing the exact concentration of glucose needed will benefit other researchers who may want to maximize the growth of their E. coli cultures by adding as much glucose as they can in their medium without using too much glucose to slow growth. The hypothesis was that the concentration of 64% of glucose per 100 mL of water would reduce the number of E. coli colonies that form in the liquid LB medium. The control concentration was 0%. Falcon tubes with LB ampicillin solution were prepared, and were made to be 0, 1, 4, 16, and 64% glucose. Ten test tubes were filled with 5 mL of LB solution from the falcon tubes at a time, as well as a varying amount of culture to ensure an equal amount of E. coli per test tube. One mL of liquid was taken from each test tube and squeezed into a cuvette in order to measure the optical density (OD) through a spectrophotometer. Then, the ODs were measured every 2 hours of incubation, up to the 1/1000th place. The ODs were recorded in a data table, and this process was repeated until each independent variable had 30 complete trials. The mean ODs were 2.5421 for 0%, 2.4714 for 1%, 2.4012 for 4%, 1.3073 for 16%, and 0.0483 for 64% glucose. On average, the optical density shrunk as the concentration of glucose in the liquid medium grew, so the experimental hypothesis was supported. The null hypothesis of no significant difference was tested using an ANOVA test, and the null hypothesis was rejected.

Kaitlin Madison -The Effect of Conjugation Time on Area of Bacteria Growth
Individual

Antibiotic resistance is a critical issue that poses a significant threat to the medical community worldwide. Despite the advancement of modern medicine, the misuse of antibiotics has led to an alarming increase in antibiotic resistance. The purpose of this experiment is to provide valuable information to medical professionals regarding the length of time it takes bacteria with resistance to two of the most used antibiotics, ampicillin and tetracycline, to conjugate and pass along antibiotic resistance. It was

hypothesized that if tetracycline resistant *Escherichia coli* and ampicillin resistant *Escherichia coli* were left to conjugate, then at ten minutes, the area of growth would be the greatest because when bacteria replicate, which can happen at a minimum approximately every four minutes, they spread their genes. With more bacteria, the frequency of conjugation will increase and thus the area of bacteria containing antibiotic resistance will also increase. This experiment was conducted under professional supervision in a National Institutes of Health laboratory, where conjugation was tested at one, two, three, four, five, and ten minutes. The results obtained from the experiment support the hypothesis as the mean area of colony growth was proven to be the highest at ten minutes. Data also showed that the difference between bacterial growth at five and ten minutes was statistically significant, thus showing that once antibiotic resistance occurs, it will spread rapidly.

Christopher Miller - A Comparison of Copper, Copper Alloys, and Stainless Steel in Bacterial Contact Killing Ability
Chesapeake Bay Governor's School

HAIs (hospital-acquired infections) are a problem in the modern healthcare setting. They are a major source of illnesses today. Copper and its alloys may be part of the solution. These metals can be used in high-touch areas to significantly reduce bacteria. This study aimed to demonstrate this idea. Pure copper was compared to copper alloys and stainless steel to determine the best choice for use in hospitals. *E. coli* and *M. luteus* were chosen to represent gram-negative and gram-positive bacteria. Based on previous research, it was hypothesized that pure copper would have the highest antimicrobial power and stainless steel would have the least. Our results confirmed this for short-term exposure of metals to bacteria. Copper and its alloys had a clear effect on *M. luteus*. This was seen again in long-term exposure, with copper having the greatest effect on *M. luteus* over time. Stainless steel had little to no effect on both bacteria. *E. coli* results were less clear for both short and long-term exposure tests. This supports the use of copper or its alloys in hospitals. These results suggested that these metals could save money and lives for hospitals over time by preventing needless infection.

MCB - Microbiology and Cell Biology - C

First Place

Samvrit Rao - In-vitro aided Computational Approach to identify Preclinical Drug Targets to treat Glioblastoma Multiforme (GBM)

Individual

Glioblastoma multiforme (GBM), is a highly malignant and prevalent form of brain cancer that continues to be largely incurable despite advancements in treatment modalities. The 2-year survival rate for individuals afflicted with GBM is approximately 18%. Recent studies have revealed that intercellular communication channels, known as Tunneling Nanotubes (TNTs), play a crucial role in the progression of GBM by facilitating the transfer of tumorigenic materials, thereby rendering the tumor resistant to treatment. The primary goal of my research project was to identify novel molecular drug targets using in-vitro aided computational approaches to prevent transfer of tumorigenic cargo through the TNTs between treatment-resistant and naive-healthy cells, to achieve GBM remission. Glioblastoma stem cells from autopsy tissue were cultured with naive astrocytes, laser micro dissected to analyze TNTs and omics-aided pathway analysis was performed to identify a key molecular drug target, JMJD8 (Jumonji domain containing 8), which was confirmed through Western Blot and immunohistochemistry. Further, computational analysis using Tumor Cancer Genomic Atlas database revealed that the drug, Paclitaxel, alters expression of JMJD8 through secondary mediators, inferring that it can be repurposed to target TNTs. Additionally, by computationally reverse engineering the search, having Vinblastine and Cytochalasin as anchors, 5 possible novel modifiable drug targets were identified. In summary, this study identifies a key molecular drug target, JMJD8; showcased that Paclitaxel could be repurposed to achieve GBM tumor remission and brought to attention 5 additional molecular targets. These novel drug targets and repurposed drugs can potentially alter GBM tumor progression and increase survival.

Second Place

Ethan Ririe - Investigating the Impact of Parasitic Worm Secretions on Anaphylaxis

Blacksburg High School

A sharp rise in food allergies during the last century has left millions with this chronic, often life-threatening condition. In fact, nearly all known autoimmune diseases are being diagnosed at higher rates than ever before, even after accounting for improvements in diagnosis techniques. Leading theories attribute this rise in immune disorders to a lack of exposure to “Old Friend” pathogens that evolved alongside humans for millennia. This study attempts to prove the veracity of the “Old Friends” hypothesis by reintroducing human tissue to the conditions created by *Necator Americanus* infection, determining whether the presence of *N. Americanus* is able to “undo” existing autoimmune disorders.

This study simulated *N. Americanus* infection using the two major secretory products of the helminth, cytokines IL-4 and IL-10. *Americanus* has been shown to be able to inhibit the anti-parasitic effects of the body's IgE antibody pathway through a complex mixture of molecules found in the parasite's secretions. Because IgE is also responsible for activating mast cells in chronic inflammatory disorders, it was theorized that parasitic worm secretions would be able to alleviate inflammation through IgE inhibition. The cytokines IL-4 and IL-10 were administered to blood samples and an enzyme-linked immunosorbent assay (ELISA) was used to detect the presence of key inflammatory molecule tryptase. Optical density data gathered by microplate reader showed that there was a significant decrease in inflammation through IL-4 stimulation but not through IL-10 stimulation.

Third Place

Kriesh Tivare - Novel Approach for Modulating the Antibiotic Response and Growth Behaviors of Bacteria Using Oscillating Compound Magnetic Fields

Individual

This study investigates the repercussions of varied magnetic fields on antibiotic susceptibility and growth behaviors of Gram-negative (*Escherichia coli* K-12, *Enterobacter aerogenes*) and Gram-positive (*Bacillus subtilis*, *Staphylococcus epidermidis*) bacteria with the ultimate goal of potentially developing life-saving antibacterial non-invasive treatment options. The experimental design encompasses the modulation of bacteria using magnetic fields produced by four waveforms (15 Hz & 50 Hz) with frequency components ranging between 15 Hz - 600 Hz, using waveforms (Sine, Sinc, and 2 complex waveforms) to comprehensively assess their effects on bacterial responses with exposure periods of 12/24 hours. Antibiotic susceptibility testing was employed to evaluate the magnetic fields' impact on the efficacy of common antibiotics: Ampicillin, Streptomycin, and Penicillin (10mcg each) against the bacterial strains influenced by the magnetic fields. Furthermore, growth behaviors were assessed to illuminate differences in the cell wall functions of Gram-positive and Gram-negative bacteria. The Sinc wave generally decreased both bacterial groups' antibiotic resistance, decreasing their resistance to Streptomycin (Gram-positive by 59.4% and Gram-negative by 8.3%). It also formidably increased *S. epidermidis*' susceptibility to Streptomycin (128.57%). On the other hand, the Spec1 wave made both groups more resistant to Penicillin (28.5% Gram-negative, 10.5% Gram-positive) and Ampicillin (10.5% Gram-negative, 18.4% Gram-positive). The Sine wave had the least impact, having mixed results among the different bacteria. The outcomes of this research hold promise for the advancement of life-saving antibacterial therapies, as well as the further implementation of microbial modulation strategies within industrial applications.

Honorable Mention

Ben Thomas -The Effect on the Growth of *Escherichia coli* Through the Presence of *Streptomyces griseus*

Central Virginia Governor's School for Science and Technology

The purpose of this study was to test the viability of the bacterium *Streptomyces griseus* as an inhibitor of the pathogenic bacterium *Escherichia coli*. *E. coli* has the ability to develop a resistance to antibiotics, so finding alternative methods of treatment is important. Two groups from the same test tube culture of *Escherichia coli* were used. Each group of *E. coli* was inoculated into a petri dish using the Kirby-Bauer method of spreading, with distilled water being added to the control cultures, and *S. griseus* being inoculated into the experimental cultures. After inoculation the petri dishes were sealed, flipped, and placed into an incubator. After 24 hours, the petri dishes were removed and the zones of inhibition for each culture were measured. The co-culture of *E. coli* and *S. griseus* produced an average zone of inhibition measuring 28.5 mm, while the culture of *E. coli* and distilled water produced an average zone of 0.38 mm. A two-sample t-Test, with an alpha value of .05, revealed a p-value of 3.990×10^{-27} . This value determined that the data was statistically significant and supported the research hypothesis that when *Escherichia coli* is co-cultured with *Streptomyces griseus*, the *S. griseus* will inhibit the growth of the *E. coli*. The results showed that *Streptomyces griseus* is an inhibitor of *Escherichia coli*.

Honorable Mention

Emily Yang -Type I γ Phosphatidylinositol Phosphate 5-Kinase Regulates Hippo Signaling Pathway

Mills E Godwin High School

Hippo pathway controls organ-size and potentially contributes to cancer progression. Hippo signaling causes the phosphorylation of YAP1 (Yes-associated Protein 1), a transcriptional co-activator. Phosphorylated YAP1 binds to 14-3-3, directing YAP1 towards degradation. Once Hippo is deactivated, YAP1 translocates to the nucleus and enhances transcription of the oncogene TEA domain family members (TEAD). YAP1 overexpression causes resistance to chemotherapeutic agents by promoting insensitivity to apoptosis and allowing cells to overcome contact inhibition. Recent research suggests that type I-gamma phosphatidylinositol phosphate 5-kinase (PIPKI γ) can interact with and regulate YAP1. Thus, it is necessary to determine whether PIPKI modulates YAP1

expression, phosphorylation, degradation, and downstream signaling. For this study, UM-SCC-1 and Cal27 cells were transfected with siRNA to knock down PIPKly, PIPKly5, and PIPKly2 expression. Western blot was used to measure protein levels, while real-time PCR was used to measure mRNA expression. Co-immunoprecipitation assay was conducted to determine PIPKly subunits and YAP1 interaction. We show that PIPKly and its sub-families may play an unanticipated role in cancer development by regulating YAP1 signaling. In PIPKly5, UM-SCC-1 and Cal27 cells, the transcription levels of YAP1 target genes and protein expression are markedly elevated. This shows that PIPKly, PIPKly5, and PIPKly2 have a universal role in modifying YAP1 signaling in various species. PIPKly subfamilies are directly linked to YAP1 according to a co-IP result. These results demonstrate a new role for PIPKly5 in the immune system. In future studies, the function of PIPKly5 in YAP1 modulation will be determined through sub-cellular localization and YAP1 nuclear translocation.

Honorable Mention

Alice Zhang -The Deficiency of Acid Ceramidase Promotes Intracellular Nanovesicle Biogenesis Contributing to Aortic Stiffness

Mills E Godwin High School

The purpose of the study was to investigate the accumulation of ceramide in the biogenesis of intracellular nanovesicles and its potential role in integrin recycling during aorta stiffness. The aorta is an artery that serves as an elastic chamber and coordinates with the heart to drive blood forward during the systolic phase of the cardiac cycle. Arterial stiffness could decrease vessel compliance, which plays a role in vascular diseases such as atherosclerosis. Aortic mechanical force is dependent on the interactions between aortic smooth muscle actin and fibronectin. Their interactions are bridged by the protein integrin, a transmembrane receptor protein that is recycled by intracellular nanovesicles (INVs), which are made through the lipid ceramide. Two different types of SMCs were used in the experiment: wild type SMCs and acid ceramidase knockout (ACKO) SMCs. WT SMCs were treated with Dimethyl sulfoxide (DMSO) as a control, palmitic acid, and a combination of palmitic acid and carmofur. ACKO SMCs were treated with DMSO as a control and palmitic acid. Palmitic acid is a substance that can serve as a substrate for ceramide biosynthesis, while carmofur is an inhibitor of acid ceramidase, an enzyme that hydrolyzes ceramide. With carmofur, the breakdown of ceramide is reduced. It was hypothesized that if there was an increase in ceramide accumulation by palmitic acid or the deletion of acid ceramidase, then there would be an increase in nanovesicle biogenesis and integrin recycling which intensifies mechanical force in aortic stiffness. A nanosight analysis was done of the SMCs, and it was shown that INVs increased markedly in ACKO SMCs treated with palmitic acid and WT SMCs treated with carmofur and palmitic acid. A Western blot was performed on the

collected cells to analyze integrin levels and demonstrated that increased INVs displayed a higher level of integrin. Using confocal microscopy, immunofluorescence images of TPD54 (an INVs marker) and integrin were visualized. The fluorescence intensity of TPD54 and integrin significantly increased in ACKO SMCS treated with palmitic acid and in WT cells treated with carmofur and palmitic acid, supporting the research hypothesis.

Ngo Tan An Nguyen -The Effect of Obstacles on Slime Mold Navigation Abilities
Mills E Godwin High School

Slime molds are single-cell organisms. (It is important to note that Slime molds are not true fungi and are not mold. They are single celled multi nuclei amoeba. There was no mold involved in this experiment). However, the way they navigate to find the most optimal pathway towards their food source astonishes scientists. Multiple studies have been conducted to better understand this navigation ability and apply it to real life in multiple fields such as transportation. In 2010, a study researching slime molds tested the efficiency of slime molds by comparing the Tokyo railway system and the system slime molds built. At the end of the experiment, the system built by many highly skilled engineers was found to be like the system the single-celled slime molds built. In the future, slime mold algorithms will be used to take a person from point A to point B, and so on. However, walls or other obstacles can change the time it takes for slime molds to reach their food source. This can lead to a variety of outcomes, such as never reaching the goal of expending a longer amount of time to reach the goal than without obstacles. Therefore, this study's purpose was to test the hypothesis that obstacles would hinder the growth of slime molds.

Sofiya Iliassov, Heaven Ferdinando -The Effects of Sine versus Sawtooth Ultrasonic Sound Waveform Administration on Necrosis in *Escherichia coli* K-12 and *Lactuca sativa* var. *capitata*
Academies of Loudoun

Pathogenic strains of *Escherichia coli* (E. coli) bacteria cause disease and death in severe cases when the E. coli produces toxins that harm the inner organs. It is a global problem that has been especially prevalent in recent decades. Although there are current preventative pre-treatments of E. coli in leafy produce, including sine ultrasound, sawtooth ultrasound is more cost-effective, reliable, and contributes to a lower carbon footprint. 30 E. coli K-12 samples were used in each experimental group to test the capacity of two ultrasounds (sine and sawtooth) and in the control group. Then, in another experiment to test cell death caused by the treatment, 60 iceberg lettuce segments were used in the experimental and control groups. As of February 2024, the sawtooth group median was 20, the control was 27.5, and the sine was 26. The

Kruskal-Wallis test (non-parametric) revealed a p-value < 0.01 , indicating extreme confidence that there is a difference between groups. The most inhibitive waveform has yet to be determined. A median of the experimental and control groups and a p-value (Mann-Whitney U test) concerning the iceberg lettuce groups have yet to be established. Research is ongoing with treatment on iceberg lettuce and additional E. coli K-12 group trials.

Carsyn Roark -The Effect of Water and Temperature on the Growth of Bacteria in Powdered Infant Formula

Central Virginia Governor's School for Science and Technology

The purpose of my study was to determine how different types of water at various temperatures affect the bacterial growth in infant formula. Infant formula was added to each water then kept at their respective temperatures, refrigerated ($2-4^{\circ}\text{C}$) and room temperature (about 20°C). After 24 hours, the solutions were incubated for approximately 72 hours. This process resulted in 70 trials. Pictures were taken of each dish and run through a colony-counting program. A Two Factor: ANOVA determined significance between both water and temperatures (p-value $=4.3 \times 10^{-11}$ and 9.7×10^{-8} , $\alpha=.05$). A Tukey test was then performed on the average means for each group to determine which groups held significance. This resulted in a Dmin value of 90.1, which determined 27 out of 31 were statistically different. The groups that did not contain a significant difference were refrigerated tap and well waters, refrigerated tap water and purified water without formula, refrigerated well water and purified water without formula, and room temperature purified and refrigerated purified waters. The research hypothesis stated, "If tap, well, spring, and purified water are added to infant formula under room temperature conditions then, tap water will have the highest number of bacterial colonies." The research hypothesis was not supported by the data. The water with the most colonies was room temperature well. The results suggest that water and temperature do influence bacterial growth in infant formula.

Kaylee Rojas-Duran -The Effect of the Soaking Solution on the Mass of the Egg
Arlington Career Center

The purpose of this project was to understand the concept of osmosis and cellular transport in action to see if varying the solutions an egg soaks in would affect its mass as it changes by gaining or losing water. Three different eggs were each soaked in three different solutions (distilled water, white vinegar, and corn syrup) over three days. Each egg was weighed on a digital balance, and then placed in its own dish. 500 mls for each dish of the three liquids was then poured over the egg. The egg and dish were

completely covered and left untouched for twenty-four hours. The egg was removed from the solution, massed, and then returned to the solution for a total of seventy-two hours, and the egg was massed every twenty-four hours. The egg in the white vinegar solution increased roughly 1.8% per day, the egg in the corn syrup decreased roughly 2.4% per day, and the egg in the distilled water increased roughly 1.5% per day. The reason the egg in the distilled water and the white vinegar increased in mass is because they contained a greater concentration of solutes than the solution the egg was sitting in, so water entered the egg, and caused a gain in mass. While white vinegar is an isotonic solution, the distilled water is a hypotonic solution so water just enters into the egg. The reason the egg in the corn syrup decreased in mass is because the solution had a greater concentration of solutes than the egg did, so water left the egg, resulting in a loss of mass. Corn syrup is also a hypertonic solution and water is just leaving the egg. One possible experimental error was the exactness of the timing during the experiment. It was difficult to measure the mass precisely every twenty-four hours. Improving the precision of that part of the experiment would result in greater accuracy. Going further with this type of experiment, it would be interesting to explore how these solutions, and others, affect plant cells instead of animal cells.

Ann Waterworth - Effects of Different Brands of Sunscreen on *Escherichia coli*
Central Virginia Governor's School for Science and Technology

The purpose of this research was to discover what brand of sunscreen constitutes the most harm to the environment, aquatic life, and wildlife. Also providing companies and consumers with the information to recognize which brands and chemicals impair the environment. To discover which brand of sunscreen produces the most harm, a mixture of sunscreen and water was placed in microfuges along with the bacteria itself. They were diluted and placed onto nutrient agar plates. After collecting how many colonies were present for each trial, a one-way ANOVA test was used to determine if there was a significant difference between the groups. However, the results from the ANOVA test did not show any significant difference between the control, Sun Bum, Neutrogena, and Banana Boat, due to the p-value being .051 and the alpha of .05. But there was a distinct difference between the mean values, leaving room for more questions about if the results were significant or not. The research hypothesis: Neutrogena, the sunscreen that contains the most chemicals and toxins, will inhibit colonies the most, was not supported by the results of the ANOVA but, from the difference of averages there was room for discussion if the hypothesis was supported or not supported. Due to the very small difference between the p-value and the alpha value as well as the difference between the mean values, the sunscreen inhibited the number of colonies and posed a threat to the environment.

PHY - Physics and Astronomy - A

First Place

Allyson Laub - A Comparison in the Quality of Cane and Synthetic Oboe Reeds
Central Virginia Governor's School for Science and Technology

The purpose of this study was to assess the availability of a high-quality and affordable synthetic oboe reed. Three synthetic oboe reeds were compared with a traditional cane reed used as a control. Two methods of producing sound from the oboe reeds were utilized; First, data was collected from the sound when each reed was crows (not played on an oboe). Then, data was collected from the sound produced when the reed was inserted into an oboe and played at 'concert A4'. Twenty total trials were executed, with each reed being subjected to ten crowing sessions and then ten playing sessions per trial. A Vernier sound sensor measured the frequency of the sound produced and the data was analyzed determining the root-mean-square value for each trial. This data was subsequently recorded and then used to perform two single-factor ANOVA tests to determine whether the data was statistically significant. After p-values of .0002 and 3.346×10^{-16} were collected and compared to an alpha value of .05, it was concluded that there was significance. Post-hoc Tukey tests identified the control reed's significant difference from all the synthetic reeds when crows and played. Additionally, the Emerald reed showed a significant difference from the Advantage reed when played. The results supported the hypothesis that the traditional cane reed would exhibit greater quality than its synthetic counterparts. In conclusion, a synthetic reed can perform with equal quality to traditional cane reeds were not determined in my research.

Second Place

Alexis Covington - Effectiveness of the Radial Velocity Method Based on Changing Velocity Utilizing the Doppler Effect
Collegiate

One of the most frequently used ways to detect exoplanets is through the radial velocity method. In order to improve the reliability of the method, an increase in the precision and knowledge regarding the Doppler Effect is needed. This research will add to the current body of knowledge relating to the radial velocity method and the Doppler shift phenomenon, addressing some of the limitations and contradictions outlined by the reviewed literature. It hoped to answer the question: "What is the effect of a change in

velocity on a change in frequency?”. It also hoped to address the precision of this observed frequency shift. The independent variable was the velocity of the cart, while the dependent variable was the measured frequency shift. A cart was dropped from various heights at the top of a ramp, moving towards a microphone that measured the observed frequencies. An FFT graph was then created from that raw data, and the max frequency was recorded. An ANOVA test was done on the frequency shifts, and a $p < 0.05$ indicated significant differences between the different velocity trials. This experiment adds to the body of knowledge regarding the Doppler effect and the radial velocity method and suggests that a high level of precision is achievable. There are a few threats to validity and limitations in the experiment regarding the methodology available in a high school lab setting, including low data precision and the use of sound rather than light. However, there are a few recommendations regarding future versions of a similar experiment, including using different recording instruments and improving the synchronization of the methodology setup.

Third Place

Allison Ekiert -The Effect of Various Types of Goggle Straps on the Elasticity of the Straps

Clover Hill High School

The purpose of this experiment was to determine which strap on swimming goggles had the most elasticity. There are many kinds of goggle straps, and all of them stretch different amounts and snap at different points. This is good information to know when choosing the right type of goggles and strap. The hypothesis said that the bungee straps would have the most elasticity. To perform the experiment, the goggle strap was looped through a circle weight, and fifteen centimeters of the strap were measured. The strap was secured to the plywood, with the fifteen centimeters with the weight hanging off the side. The weight was released, and the strap was measured after having been hanging for one minute. The results showed that after being stretched, the bungee strap was an average of 21.67 cm long, the braided straps were an average of 42.47 cm, Speedo Vanquishers were 23.50 cm, Speedo Speed Sockets were 28.00 cm, Arenas were 19.72 cm, and Speedo Vanquisher Juniors were 24.00 cm. The braided strap had the most elasticity, and the Arena strap had the least elasticity. The null hypothesis was rejected, and the data did not support the research hypothesis.

Honorable Mention

Declan Leighton -The Effect of Voltage and Nozzle Size on the Force Generated by Radial Magnetohydrodynamic Drive

Individual

Magnetohydrodynamic drive (MHD drive) is an effect that uses Lorentz force to accelerate a fluid. MHD drive performs this by using a magnetic field and an electric current, but no moving parts which makes it virtually silent. Hypothesis A was if the voltage increases in a radial MHD drive, the force generated will increase at a nonlinear, plateauing rate because the electrolysis reaction will surpass that of the Lorentz force effect and result in a plateau of the generated force. Hypothesis B was if the nozzle throat size is decreased, then the force generated by MHD drive will increase because the nozzle will accelerate the fluid as it exits the radial MHD drive increasing the force. Using a custom designed and 3D printed radial MHD drive, the experiment was conducted, and 60,000 data points were collected. The following conclusions were drawn Hypothesis A was confirmed with a P value of <0.01 . Hypothesis B was disproved because the force decreased when the nozzle throat diameter was decreased. Additionally, a P value of <0.19 was recorded leading to less confidence in the data. The MHD drive was able to produce a max force of 0.116 newtons at 30 volts without the nozzle. This indicates that further research could show that a radial MHD drive has the potential to revolutionize oceanic transport and nanotechnology.

Honorable Mention

Kate Corazzini -The Effect of Different Types of Soccer Ball Casings on Force of Impact
Clover Hill High School

The purpose of this experiment was to determine the effect of different types of soccer ball casings on the force of impact. Understanding this concept helps soccer leagues determine the best ball casing to use as it pertains to causing head injuries. To measure the force of impact, the balls were placed in a slingshot and catapulted into a force plate. The force plate measured the force of the balls in Newtons(N). The control of the experiment was the polyurethane, and the independent variables were polyvinyl chloride, synthetic leather, and combined casing. Each of the forces were recorded in a data table and converted to the Newton unit by multiplying the kilograms by 9.81. The process was repeated 30 times at each level. The mean for the control polyurethane casing was 221.052 N. The polyvinyl chloride casing had a mean of 208.626 N. The synthetic leather casing had a mean of 218.109 N. The combined casing had a mean of 197.508 N. After the data was collected, an ANOVA Test was conducted to test the significance of the data. The ANOVA Test results concluded that the null hypothesis was rejected because the P-value was less than the significance level. The research hypothesis was that the polyvinyl chloride casing would have the greatest force of impact. This hypothesis was not supported.

Samuel Narron -The Correlation between Globular Clusters and Millisecond Pulsars
Central Virginia Governor's School for Science and Technology

The purpose of this study was to gain data on both millisecond pulsars and globular clusters by examining the correlation between the properties of globular clusters and the amount and type of millisecond pulsars within them. A Python program was able to determine whether there was any possible significance for either a linear or exponential fit when graphing these properties. This data came from two public databases and one research paper. The Python program used the Pearson Correlation Coefficient test to determine any possible significance of the fits. This test gave p-values which were compared to the alpha value of .05, these p-values represented relationships of the properties such as remaining lifetime to the amount of millisecond pulsars within the globular cluster. The research hypothesis was partially supported as many, though not all, of the properties possessed significance with each other. In summation, a globular cluster's properties may possess a potential to affect the amount and type of millisecond pulsars within them.

Sid Jakoubek -Investigating the Factors Which Allow for the Stability of Planetary Orbits in Binary Star Systems Using Numerical Simulations Based on Initial Planetary Positions
Blacksburg High School

The purpose of this study was to find what requirements or necessities, if any, were needed for planets to form and hold a stable orbit within a binary star system by using simulations to model their orbits. The conclusion that was come to is that, from the simulations that have been run, a planet must, at minimum, be at a high distance from the center of gravity of the system in order to maintain a somewhat stable orbit. This conclusion has been reached by looking at the data gathered from simulations, which showed that the further the planet was from the center of gravity of its binary star system, the more likely it was to remain in the star system for longer periods of time. Coupled with the velocity of the planets, which got slower, the further away they went from the center of gravity, the more stable their orbits became. This shows that, in binary systems, the further away a planet is from the center of gravity of its system, the better the chance it has for it to remain within the system and hold a stable orbit.

Carson Ellenberger -The Effect of Counterweight and Arm Length on the Height and Distance a Trebuchet Projectile Travels
Clover Hill High School

In the past, trebuchets were massive mechanical structures used as weapons of mass destruction. In today's world, similar catapults are used to launch aircraft that are capable of even more destruction. As a result, the purpose of this experiment was to further understand the effects that different arm lengths and different counterweights have on these devices. A trebuchet was launched 30 times with each combination of 3 different arm lengths and 3 different counterweights. The counterweights were 492 grams, 574 grams, and 656 grams. The arm lengths were 18 centimeters, 22 centimeters, and 26 centimeters. For the 18 cm arm length trials, the distances traveled were 88.8 cm (492 g counterweight), 98.9 cm (574 g), and 98.0 cm (656 g). The heights traveled were 59.5 cm, 61.5 cm, and 61.5 cm. For the 22 cm arm length trials, the distances traveled were 111.0 cm, 124.5 cm, and 141.4 cm. The heights traveled were 64.4 cm, 64.9 cm, and 65.0 cm. For the 26 cm arm length trials, the distances traveled were 40.4 cm, 124.6 cm, and 133.0 cm. The heights traveled were 63.2 cm, 70.5 cm, and 74.3 cm. The experimental hypothesis said if a projectile was launched from a trebuchet, it would travel farther and higher the longer the arm length and heavier the counterweight. The experimental hypothesis and the null hypothesis were rejected. The results were found to be significant with a Two-Way ANOVA test.

PHY - Physics and Astronomy – B

First Place

Minghui Zhang, Maxim Lupariello, Louis To - Electro-Stopping Power
Governor's School @ Innovation Park

The aim of this research project is to develop and test an electromagnetic braking system for bicycles that operates without mechanical friction. Traditional friction brakes in bicycles are fundamentally limited by physical wear and tear. The alternative system employs a synergy of electromagnets to generate a counter-torque through the interaction between eddy current and magnetic field that decelerates the wheel through non-contact means. Upon actuation of the brake lever, an electric current powers the electromagnets, initiating the braking force. This study's empirical component involves the measurement of the time needed to stop the bike using the electromagnetic system. Electromagnets were placed in different configurations in the two holes (one on top and one on bottom) on each stand that provided support to the wheel and the disks: No electromagnets, one electromagnet in the bottom hole, two electromagnets in the bottom hole of each side, and two electromagnets in the top and bottom holes. After conducting five trials for each configuration, the average stopping time of the bike wheel was recorded for each configuration: 5.298 s for no electromagnets, 3.74 s for one electromagnet, 2.746 s for two electromagnets in the bottom slot, and 2.394 s for two electromagnets in both the top and bottom slots. That

data was then compared with the times for a traditional friction brake bike system, and the conclusion that a traditional friction brake bike system has a shorter stopping time than that of an electromagnetic braking system was drawn. An ANOVA test resulted in $p < .001$, suggesting there were statistically significant differences between different electromagnet configurations. A Tukey test was then performed to find where statistically significant differences exist, and the result indicates that there is a statistically significant difference between all configurations except for the combination of two electromagnets in the bottom slot of both sides and two electromagnets in the top and bottom slots for one side.

Second Place

Amna Zakriya -The Effect of Solar Energetic Particle Events on the Earth's Geomagnetic Field

Mountain View High School

For centuries, physicists and astronomers have studied solar events that impact natural cycles and processes on Earth. One such phenomenon is the movement of the Earth's geomagnetic poles, which cause fluctuations in the magnetic field. The magnetic field is not naturally entirely stable; significant changes in its movement can impede electrical signals and power grids. This study aimed to determine the relationship between Solar Energetic Particle (SEP) solar events and their effect on this geomagnetic field using figures from global databases. There was found to be a statistically significant causal association between the two variables, in both amount per year and intensity of the solar energetic particle events, however it was also proven that the quantity of the SEP events had a greater role in causing a fluctuation in the geomagnetic field than the intensity of the SEP events did. This defined influence allows scientists to make more accurate predictions about geomagnetic changes, and in turn, electrical variations.

Third Place

Ella Schmutz -The Effect of Lead, Polyethylene, and Water on Blocking Cobalt-60 Gamma Radiation

Central Virginia Governor's School for Science and Technology

The purpose of this study was to compare the ability of various shielding materials to block radiation emissions. Shielding materials included polyethylene, lead, 100 mL of water with polyethylene, and 100 mL of water with lead. A radiation monitor was used to detect the radiation count of a Cobalt-60 sample passing through each lead and polyethylene shield during a ten-minute interval. Each trial was repeated in a beaker of

100 mL of water. The study's results suggested that polyethylene, lead, water with polyethylene shields, and water with lead shields all significantly blocked radiation emissions, but that 100 mL of water combined with lead shields blocked the most radiation. Single-factor ANOVA statistical tests were performed on each independent variable. The tests resulted in p-values of 8.57×10^{-6} for polyethylene shields, 1.2×10^{-53} for lead shields, 5.23×10^{-11} for polyethylene shields with water, and 2.83×10^{-34} for lead shields with water. These were compared to an alpha value of .05, indicating a significant difference between groups. The p-values were lower than the alpha level, so Tukey tests were performed on the data, which suggested that the water with lead shields were most effective. The research hypothesis that if lead is used as a radioactive shield, then it will block the most gamma radiation, was partially supported by the data. While the lead shields performed better than the polyethylene shields, the shields that worked best were the water combined with lead shields.

Honorable Mention

Kareem Mukhtar -The Effect of Different Tennis Balls on Contact
Mills E Godwin High School

Four types of tennis balls were studied to learn the different effects of the type of tennis balls on the types of contact they made. Tennis balls come in all shapes and sizes, however these four are used in different situations although they look similar. Five Extra Duty, Regular Duty, High Altitude, and Pressure less tennis balls were loaded into a tennis ball machine. The bounce height and speed the balls were going at was measured and recorded, this was repeated 5 times for each ball. This experiment has no control as there isn't a default tennis ball. Whatever tennis ball a person uses is based purely on personal preference. It was hypothesized that the Regular Duty balls would move the fastest and bounce the highest. The results showed that the Regular Duty balls had the fastest average ball speed and High-Altitude balls lost the least amount of speed. Extra Duty balls had the highest average bounce height. A t-test was conducted on both data sets, and it was revealed that all the data for bounce height was significant while none of the data for the ball speed was significant since all the data points were the same. The research hypothesis for the ball speed was supported, but the research hypothesis for the bounce height was not. This data can be used for future research on how different ball materials can affect the way it reacts to its environment.

Honorable Mention

Samantha Styles -The Effect of Painting Various Types of Surfaces with the Same Acrylic Paint on the Degree of Fading Over Time, Measured by RGB Difference Over Time
Clover Hill High School

The question addressed in this experiment was how much paint would fade when applied to various household and artistic surfaces. The purpose of this experiment was to find if the same acrylic paint faded at a different rate depending on the surface when applied to plywood, cardboard, printer paper, and canvas. The hypothesis was that if plywood, cardboard, printer paper, and canvas that had been painted were exposed to the same amount of UV light over time, then the paint on cardboard would experience more severe paint fade than other surfaces due to its high amount of light absorption and bonding qualities. Thirty squares each of plywood, cardboard, paper, and canvas were painted with the same type and amount of red paint and placed under UV lights for 11 weeks. The RGB values for each square were measured using a RGB scanner app and averaged for each surface every week. The measurements at week 1 (control) and week 11 were compared to test for differences. After 11 weeks, the mean red values of plywood, cardboard, paper, and canvas changed from 215.0 to 230.0, 214.9 to 236.3, 201.1 to 216.1, and 200.1 to 220.9, respectively. Blue and green values also increased, generally. ANOVA tests were conducted to determine significance, and the tests found that the data was statistically significant. The experiment concluded that various surfaces cause paint to fade at different rates. All of the surfaces generally became lighter over time, and the change in blue and green values shows that some level of discoloration occurred due to fading. The null hypothesis was rejected, and the research hypothesis was supported by the data because cardboard exhibited the greatest red value difference after 11 weeks, with a difference of 21.4.

Kaya Spitzak -The Effect of the Day on the Intensity of Transient
Arlington Career Center

The purpose of this experiment is to learn more about the things in the universe that as humans we don't yet understand. The sky was observed over a period of several days and looked for events that are high enough intensity to stand out relative to the background. The hypothesis was that the highest intensity events would be clustered together. A radio telescope was set up outside and observed radio signals for a few hours each day. The data was recorded to a table and graphed. This process was repeated for five days. There was a range of brightness from 0.959 counts on day two to 0.275 counts on day three. Even the faintest source, 0.275 counts on day three, was still 9.5 times brighter than the noise level. On day two we had our lowest intensity event (units are counts) but only one day later we had our highest Intensity event. This shows that the brightest events were not clustered together and over a short period of time the brightest events were very spread out. The hypothesis was rejected.

Elijah Tomiak - Change of the Coefficient of Friction on a Tennis Court Before, During, and After being Washed Off with Water
Southwest Virginia Governor's School

In tennis, the friction between the player's shoe and the court is very important. Players are constantly accelerating, decelerating, and switching directions. Because of the magnitude of this interaction, previous work has been done to understand how different shoes can affect it. However, very little has been done to compare the friction when the court is in a different state. This study looks at whether washing off a court can make the coefficient of friction (COF) greater, essentially showing that there is more traction on a cleaner court. To test this, a shoe was connected to a force probe and pulled from a static state on the surface of a tennis court. The same section of court then had water poured on it, and the measurements repeated for a total of three sample groups: original/unwashed, wet, and dry. These groups were compared using the ANOVA test, along with a follow up Tukey HSD test. From this, it was shown that the COF of the dry court was significantly lower than the COF of the original court. This means that a cleaner court is slicker than an unwashed one, which is the opposite of the expected result, and leaves more questions than answers. It is likely that some unknown variable or flaw in the experiment influenced these results, so more testing would need to be done for a more concrete conclusion.

Lauren Winters -The Effect of Using a Colored Pencil on Various Types of Art Media on the Brightness or Dullness of Color Exhibited
Clover Hill High School

The question that was addressed in the experiment was which art media would be the best for capturing the colors of colored pencils. Knowing which art material absorbs the most color from colored pencils allows artists to choose which art media to use for projects and artwork. Finding an affordable art medium to showcase the beauty of colored pencils would allow artists to save money while also producing higher-quality work. The purpose of this experiment was to see which art media would produce the brightest or dullest RGB color value on the art media types: printer paper, cardstock, sandpaper, watercolor paper, and canvas. To measure the colored pencil markings the same across all types of art media, a simple machine was used. An RGB colorimeter was used to measure the RGB color value of the colored pencil markings on the types of art media. The five levels of independent variables were control, cardstock, canvas, watercolor paper, and sandpaper. The RGB color values were recorded in a data table, and this process was repeated until each level had thirty complete trials. The

average RGB color value produced by the control printer paper was 0.07470. The average value derived from the cardstock was 0.06784. The average value that the canvas generated was 0.3808. The average value that the watercolor paper generated was 0.0000465. The average value of sandpaper was 0.3196. Canvas and sandpaper showed the largest average RGB color value. After the data was collected, an ANOVA test was conducted to test if the data was statistically significant. The null hypothesis was rejected, because the F-statistic value was a lot larger than the F critical value. The experimental hypothesis was: if equal pressure was applied to cardstock, canvas, sandpaper, and watercolor this would result in the brightest RGB color value on canvas and sandpaper. This was supported.

PSY - Psychology - A

First Place

Emily Emanuel-The Relationship Between Musical Theatre Involvement and Self-esteem in Highschoolers

Central Virginia Governor's School for Science and Technology

The purpose of this research was to determine if there is a relationship between musical theater involvement and teen self-esteem. Data was collected from forty-five high schoolers with varying amounts of theater experience. These participants were asked to fill out a survey through Google Forms that assessed their experiences in theater, such as number of shows done, or theater arts classes taken. Each participant's self-esteem level was also measured in the survey by using questions from the Rosenberg Self-esteem Scale. The questions were set on a 4-point Likert scale and provided numerical values for self-esteem. Data was analyzed using Correlation and Regression statistical tests. The correlation coefficient of $-.316$ compared to the critical correlation value was $.3$ suggested a significant negative relationship. The regression provided a low p-value of $.034$, which was smaller than the alpha of $.05$. Although a significant relationship was found, the research hypothesis that "those with higher levels of involvement in theater would have higher levels of self-esteem" was not supported. There was a negative correlation and students with no theater experience had higher self-esteem on average than the rest of the participants. This research showed a different perspective on the relationship between the arts and self-esteem and added to the idea that students with lower self-esteem may become involved with theater to find an outlet. It opened up an opportunity to look into the relationship between the arts and self-esteem further.

Second Place

Tanusiya Debnath -The Effect of Psychotherapy on Opioid Addiction
Mills E Godwin High School

The purpose of this study was to determine if there was a correlation between anxiety and friendship quality in high schoolers. This study was conducted at a local high school in November of 2023. Students were sent a survey with two parts, one assessing anxiety, and the other assessing friendship quality. Friendship quality scores were split into five categories: Initiation, Affirmation, Vulnerability, Support, Identity Acceptance, and Overall Friendship. Each of these categories was run in a correlational test between anxiety, and each provided its own correlational coefficient. The correlation r-values were: Initiation (.005), Affirmation (-.244), Vulnerability (-.356), Support (-.005), Identity Acceptance (-.216), and Overall Friendship (-.221). With a degree of freedom value of 25 and an alpha value of .05, the critical correlation value was .396. Since none of the resulting correlation coefficients were higher than .396, it suggested no statistical significance. Having said this, the original research hypothesis proposed that: "If high school students show higher symptoms of anxiety, then they will have lower-quality friendships," but was unsupported. In conclusion, there was no significant correlation between anxiety levels and friendship quality in high school students.

Third Place

Lizzy Burgess -The Correlation Between Anxiety and Friendship Quality
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if there was a correlation between anxiety and friendship quality in high schoolers. This study was conducted at a local high school in November of 2023. Students were sent a survey with two parts, one assessing anxiety, and the other assessing friendship quality. Friendship quality scores were split into five categories: Initiation, Affirmation, Vulnerability, Support, Identity Acceptance, and Overall Friendship. Each of these categories was run in a correlational test between anxiety, and each provided its own correlational coefficient. The correlation r-values were Initiation (.005), Affirmation (-.244), Vulnerability (-.356), Support (-.005), Identity Acceptance (-.216), and Overall Friendship (-.221). With a degree of freedom value of 25 and an alpha value of .05, the critical correlation value was .396. Since none of the resulting correlation coefficients were higher than .396, it suggested no statistical significance. Having said this, the original research hypothesis proposed that: "If high school students show higher symptoms of anxiety, then they will have lower-quality friendships," but was unsupported. In conclusion, there was no

significant correlation between anxiety levels and friendship quality in high school students.

Honorable Mention

Nyomi Aboagye - The Effect of Fear on Heart Rate

Mills E Godwin High School

Fear is believed to have evolved in humans as a defense from threats. The purpose for conducting this experiment is to determine if fear has a significant effect on heart rate. This study is relevant to everyday life because an elevated heart rate can indicate underlying health problems. The research hypothesis was If test subjects are exposed to POV roller coaster video, then they will experience increased heart rate. The control was the resting heart rate of participants. Resting heart rate was used as the control because it provided a baseline for each participant. Heart rate was measured using Beats Per Minute (bpm). Measurements were taken using a fingertip pulse oximeter. The resting heart rate of participants was taken. Then, participants were blindfolded, and headphones were placed on them. Thriller music was played in headphones for 3 minutes. VR cellphone headsets were placed on participants. Participants watched POV roller coaster videos. Heart rate was measured and recorded. The calculated t values for Thriller music versus control (0.261), Claustrophobia and spider slides versus control (2.433), and POV roller coaster video versus control (0.7556). They were all lower than the table t value of 2.704. Upon further analysis, changes in heart rate in Thriller music, Claustrophobia and spider slides, and POV roller coaster video were not significant and likely caused by chance. Due to these results, the research hypothesis was not supported. These results could have been due to weak stimuli. Overall, data for fear affecting heart rate is not statistically significant.

Honorable Mention

Sydney Glover -The Relationship Between Biological Sex and Short-term memory

Central Virginia Governor's School for Science and Technology

This study aimed to examine the relationship between biological sex and the ability to recall information from short-term memory. The pool of participants in this study were biological males and females between the ages of 18 and 60. Each participant completed a Google Forms Survey with the same number of questions asking the participants to recall pictures/words. Twenty-six participants completed the Google Forms Survey: 17 females and 9 males. After each participant submitted the Google Form, the data was put into Excel to calculate the survey results. The hypothesis for

this experiment was “if males and females perform short-term memory tests, then females will consistently recall more than males.” After conducting a two-sample t-test, the results showed a p-value of .64, and comparing this to an alpha value of .05, the data showed no significant difference between the recall abilities of males and females. As a result of these findings, the research hypothesis was not supported. This study focused on determining which biological sex has the greatest recall ability when remembering pictures and sentences from short-term memory and does not support the idea that biological sex plays a key role in memory recall.

Honorable Mention

Katie Adamczyk -The Correlation Between Houseplants and Motivation
Central Virginia Governor's School for Science and Technology

The purpose of this research project was to see if there was any correlation between the time spent within eyesight of a houseplant and motivation. In order to conduct this research, human participants were used. Each participant was given a Chlorophytum comosum plant, commonly known as a spider plant, that they kept within eyesight for a measurable amount of time every day. At the end of the day, every day for two weeks, the participants filled out a Google form survey. The form collected the hours they spent within eyesight of the plant and how motivated they felt on a 1-5 scale. A correlation statistical test showed that there was a significant correlation between the amount of time spent within eyesight of the houseplant and motivation. The null hypothesis was rejected when the p-value of 5.08×10^{-28} was compared to the alpha value of .05. A regression analysis test of the data also revealed significance (p-value .035, alpha .05), which supported the research hypothesis: If the participants spend more time with the houseplant, they will have higher motivation. In conclusion, the more time spent within eyesight of a houseplant, the more motivated people can feel.

Josiah Cantrell -The Effect of Academic Performance on Symptoms of Generalized Anxiety Disorder
Central Virginia Governor's School for Science and Technology

The purpose of this research is to determine the extent to which academic performance influences symptoms of generalized anxiety disorder (GAD). The survey

population for this study consisted of 31 individuals currently enrolled in high school. The participants were invited to participate in a Google form-based survey via email. The survey consisted of questions pertaining to the student's self-assessed academic performance and feelings of GAD. Anxiety in this survey was measured on a scale of how often the participant experiences the listed prompt ranging from "not at all" to "nearly every day". The data was then analyzed through the use of a linear regression model to determine if there is a statistically significant relationship between academic performance and symptoms of GAD. The alpha value used for the statistical analysis was .05. The statistical analysis of the data yielded a correlation coefficient value of -.2169. Since this value is less extreme than the critical value of .349, the null hypothesis was retained for this experiment. In addition to this, the research hypothesis, which stated that students with a greater self-assessed academic performance would be more likely to experience symptoms of GAD in their day-to-day life, was not supported because the hypothesis suspected a correlation between the two measured variables.

Emily Hines -The Effect of Hair Color on Human Perception
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if hair color had an effect on human perception. This study was conducted using local high school students and adults who showed interest in the study. These participants were given a survey with images of six different people, consisting of three males, and three females with varying hair colors, followed by 8 questions for each image relating to topics like intelligence, attractiveness, temper, and popularity. After data collection, eight 2-factor ANOVA tests with replication were run for each question. The resulting p-values were all less than the alpha of .05, indicating significance between at least one factor of all eight tests. Following post-hoc Tukey tests, the results suggested statistical significance between hair color and intelligence, popularity, talkativeness, attractiveness, and likeliness of being CEO. There was also statistical significance between gender and likeliness to go to college, likeliness of friendship, temper, attractiveness, and likeliness of being CEO. The statistical significance between these groups supported the hypothesis that the results would support typical stereotypes of hair color. In summary, hair color did affect how people were perceived.

Annalyse Heideman -The Effect of Social and Extracurricular Activities on Students need for Academic Dishonesty
Central Virginia Governor's School for Science and Technology

As technology advances into more capable software, it is easier for students to use unauthorized assistance. The purpose of this research was to see if there was a

correlation between students who were more involved in social/extracurricular activities and their need for unauthorized assistance to complete assignments. Data was gathered through a Google Form that consisted of 12 questions asking students to categorize weekly hours spent in different activities, and then asking students how often they used unauthorized assistance, as well as what subjects they would use unauthorized assistance in. The sample population was gathered from high school students from four local high schools. Overall, the research hypothesis "If students are involved in 15-20 hours of sports, they are more likely to use unauthorized assistance on assignments," was not supported showing no significant differences between groups. To come to this conclusion, the data was analyzed through a ANOVA: Single Factor, and resulted in a p-value of .29, which is larger than the alpha value ($\alpha=.05$). This research project supported the idea that activities that students are involved in does not affect the need for unauthorized assistance, suggesting everyone is susceptible to using it equally.

PSY - Psychology - B

First Place

Taylor Jones -The Effect of Social Influence on Adolescent Decision Making
Central Virginia Governor's School for Science and Technology

The purpose of this study was to see how social pressure can affect adolescent's decision-making abilities. This study involved in person testing, requiring the participants to take a quiz, then participate in a group discussion, and then take the same quiz again. Each test had two to three participants, and four influencers who would attempt to sway the participants to change their answers. There were three "this or that" questions on the quiz with a scale for one-ten for each, one and ten representing a strong pick for one side. Overall, there were 18 participants and 18 comparable data points. Three paired T-tests were used to analyze the participant data to determine if there were significant differences in the pre and post discussion scores. The data resulted in a t- Critical two-tail of 2.1, indicating that the data was not statistically significant. The research hypothesis was not supported, since there was not an extreme enough difference for there to be a significant change. Based on the data, about 89% of participants changed at least one question value from their first quiz to their second quiz, but it was not significant enough to reject the null. Overall, the data indicated that most participants were affected by the socially influenced situation, but it was not significant enough to suggest that 75% of the participants would completely change their answers. This study helps make a better understanding of how social influence in adolescence affects teenage decision making.

Second Place

Isabella Long - The Effect of Studying and Working in the Legal Field on Emotional Well-Being

Central Virginia Governor's School for Science and Technology

This research investigated the impact of working and studying in the legal field on psychological well-being, with a focus on the relationship between the intense stressors of the field and their negative emotional health effects. The Brief Emotional Experience Scale (BEES), a scale which evaluates positive and negative emotions in order to reveal one's dominant emotional state, was used in this study to compare data from law professionals and law students to general public data. Two-sample T-tests run on both groups revealed significant differences in well-being for each, with p-values of .00089 for law professionals and .0340 for law students, both of which were lower than the alpha value of .05. These results support the hypothesis that stress in the legal field, if not managed effectively, can lead to worsened mental health states for both professionals and students. This study highlights the critical need for improved stress management strategies within the legal field, as supported by the significant decrease in well-being of law professionals and students in comparison to the general population.

Third Place

Evangeline Lloyd – The Relationships Between Religious Affiliations and Perceptions of Multiple Forms of Intelligence

Central Virginia Governor's School for Science and Technology

The purpose of this study is to show if there is a significant difference between how members of a particular faith view people of other various religions in regard to academic intelligence, emotional intelligence, and social intelligence. Participants received surveys via email with questions asking them to give a ranking score for each religion in each of the types of intelligence. Atheists received the overall lowest score with an average of 1.75 on the three-point scale and Buddhism with the highest at a 2.05 average. A two-factor ANOVA analyzing each faith's average scores and the scores for each intelligence type, with an alpha value of .05, had a p-value of .198 for the interaction but a p-value of 7.36×10^{-8} for just the overall average intelligence score of each religion. When looking if participant faith reflected different results on believed intelligence scores, only the Methodist group showed significance with a p-value of .0056. This led to the research hypothesis not being supported because each religion did not rank itself as more intelligent than the other faiths. The data tends to show that people see certain faiths as more intelligent regardless of the person participating's

faith and with no significant difference in how they view academic, social, and emotional intelligences across religions.

Arwen Kintz, -The Effect of Positive Versus Negative Portrayals of Sharks on People's Dispositions Towards Them.

Chesapeake Bay Governor's School

Predators are typically feared, which can hurt conservation efforts to protect them. Losing the top predator in an environment can devastate the entire ecosystem. This study focuses on the change in people's disposition due to the different portrayals of sharks. Human participants completed a ten-question pre-survey containing positive and negative statements about sharks. Then the participants were divided into two groups and watched a presentation. One presentation provided positive information about sharks, while the other one was negative. After viewing the presentation, the participants completed a similar post-survey, including questions about their experience with sharks. Viewing positive information caused an average increase in participant's scores. The group that saw the negative information observed an average decrease in scores. Personal experience interacting with sharks also influences how much negative information affects people. Positive past experiences caused a smaller change in scores than negative past experiences. The different portrayals of sharks do impact someone's disposition towards them based on the type of information presented.

Addison Lucas - The Impact of an Athlete's Performance in Competition On Their Perception of How They Will Perform in Future Competition

Collegiate

Success within athletics relies on not just an athlete's physical ability, but also their mental capacity to handle how they respond to tough situations. There can be a negative physical and mental effect that occurs on an athlete's body and mind after loss, and a positive one that occurs after victory (Davis, 2007). An athlete's response to success or defeat is caused by many different factors. Understanding the emotional components that drive someone's passion for their sport is also crucial in achieving full comprehension of an athlete's mindset (Bélanger et al., 2012). Through evidence in the literature, it is assumed that if an athlete loses their athletic competition, they are going to lose confidence in their ability to perform well in their next competition. In the present experiment, 86 high school athletes anonymously completed a survey of Likert Scale style questions that related to how well they had performed in that competition, factors that went into their performance, and how they believed they will

perform in their next competition. Each athlete completed the survey directly after each of their athletic competitions and also had the choice to explain each of their answers in depth. The findings of this study suggested that students who had lost their athletic competitions did have lower confidence, however only certain survey question averages were statistically significant. It was concluded that the boys had significantly higher responses to each question regarding their teammates' than the girls. Their responses to questions regarding their individual performances and their confidence for their future performances still showed higher trends than the girls but were not significant. Responses from players that won their competitions averaged higher than from the players that lost their competitions, but the difference was only statistically significant within one question about their teammate's future performances. If the sample size of data had been larger, or the data collection period was longer, it is possible that the null hypothesis for the experiment could have been rejected. Despite the lack of statistically significant findings, there are still conclusions that can be taken away from this study. This work can benefit current and future athlete's response to defeat or victory, although the original goal of the experiment was not completely achieved.

Conner Mattox -The effects of the COVID-19 Pandemic on early childhood social development

Central Virginia Governor's School for Science and Technology

The purpose of this study is to examine the effects of the COVID-19 pandemic on early childhood social development. Teachers were asked to take a survey discussing social topics within schools, focusing on how their students interacted in pre and post era COVID-19. Social topics included: Group work, class interaction, referrals, friendships, peer respect, playground and lunch time. Paired T-tests determined if there were differences in pre and post era COVID-19 social topics within the children. Compared to an alpha of .05, p values from each test (Group work- 0.012, class interaction- 0.003, referrals-0.007, friendships- 3.43×10^{-5} , peer respect-0.001, playground- 0.0001 and lunch time- 8.94×10^{-5}), found that there were significant differences in every social topic. These results suggest that children have a decrease in social development from COVID-19. This was able to then support the research hypothesis (If teachers are surveyed on pre and post era COVID-19 social topics of their classroom then there will show significant difference) suggesting that COVID-19 did impact early childhood social development.

Charles May - Relationship Between Participation in Extracurricular Activities and Stress Levels

Central Virginia Governor's School for Science and Technology

The purpose of this research study was to explore the relationship between the number of hours per week occupied by extracurricular activities and a student's stress levels. Participants from a local high school received a Google Forms survey containing short and simple questions relative to severity of stress during the time of year of the participants' respective extracurricular while managing their time with school as well. Responses were collected and data was stored in Excel, then the data was analyzed by the performance of an ANOVA Single Factor analytic test. The test gave an output that resulted in a p-value of .2027 which was compared to an alpha value of .05. Given these numbers, the initial research hypothesis that predicted students who were more occupied during the week by their extracurricular activities were more prone to suffer from higher stress levels was not supported. Overall, this study touched on a topic that can be sensitive to some by looking at past cases involved with this topic which added to the difficulty of recruitment, but the impact of study on this sort of topic covers a prevalent concern in stress among high school students. I focused on students who are more actively involved in extracurricular activities because it homed in on exploring the relationships among several external elements in teenager lives that increase risks of mental health issues.

Molly Morris -The Correlation Between Color Cues and Human Perception of Flavor
Southwest Virginia Governor's School

Color is one of the most important sensory cues when it comes to purchasing ground beef, especially when it comes to setting expectations regarding likely color and quality. Consumers discern between good and bad meat with the use of their sight. If the ground beef has any deviation from the bright, cherry-red color it is assumed to be unfit for consumption and preparation. Therefore, the objective of this study is to determine why and how color cues affect the perception of quality and taste utilizing the variable of ground beef. To conduct this study the researcher created a five-question survey using pictures of ground beef with color filters added (blue, brown, yellow, and red). The participants were asked to use the Likert scale to answer how much they agreed or disagreed with the statement "This ground beef is safe to prepare and consume." The sample size for this study was 39 participants; however, having more participants would not affect the methodology of this project. Results of the survey were statistically analyzed by the use of a Chi-Square test. This test suggested that the question of "How can manipulated color of food affect perception of its quality and flavor?" was that color can affect a person's conception of flavor. The

colored pictures, except red, were more likely to disagree with the statement “This ground beef is safe to prepare and consume.” This discovery suggests that observed color can change a person’s view of the quality and taste of ground beef. By gaining a better understanding of sensory expectations elicited by food color, researchers and producers could recognize the importance of color cues when making decisions about the products that consumers will purchase.

Natalie Patton – The Impact of Motivational Theories on Perceived Persuasion
The Mathematics and Science Academy at Ocean Lakes High School

The purpose of this study was to improve our perception and understanding of the relationship between what we see in day-to-day life and how it impacts our opinions and behaviors. This will be described using different psychological motivational theories, such as Maslow's hierarchy of needs, optimal arousal theory, and emotional tone, in order to determine if these theories match up with how effective advertisements were. This will be determined by comparing how well each advertisement matches the motivational theory and comparing this to how effective the advertisement actually was at persuading viewers to interact with its brand or product. This can also be used to compare how well the motivational theories describe the effectiveness of advertisements against each other to determine which ones were the most similar to the results found in real life. The research found that, although some correlation was able to be confirmed between how the advertisements conformed to the motivational theories and their persuasion, the actual relationships between these were too small to give any true, useful information about what motivational theories might describe how people are most successfully motivated. This could lead to the conclusion that none of the motivational theories that were tested here have any large relationship with motivation, which could lead to questioning of many of the psychological principles that haven't been able to be successfully studied, such as these. This information is important so that we, as humans, can have a greater understanding of our thought processes and of what is most important and motivating to us.

PSY - Psychology – C

First Place

Kaliban Prasanna - Mastermind: A Novel Multi-Output Model Approach for Detecting Mental Illnesses through Natural Language Processing

Lightridge High School

Identifying and diagnosing mental health conditions such as depression, anxiety, and suicidal thoughts is growing in importance, with Natural Language Processing (NLP) emerging as a viable key to do so. This research utilizes publicly available, de-identified textual data from Kaggle, which draws this data from X (formerly Twitter) and Reddit. This research focuses on applying and optimizing the following NLP models for mental illness detection: the Naïve Bayes, Random Forest, XGBoost, and K-Nearest Neighbors classifiers. These models are then integrated into a comprehensive multi-output model, aimed to optimize efficiency. Although the individual models displayed a tendency to overfit, they demonstrated high accuracy and effectiveness in mental health detection, specifically the Random Forest Classifier. The tested multi-output models presented an array of ROC-AUC scores ranging from 0.60 to 0.93, leading to promising results overall. This research underscores the potential of NLP in screening people for mental health analysis and support.

Second Place

Riley Warner -The Effect of Social Media on Eating Disorder Prevalence in College Students

Central Virginia Governor's School for Science and Technology

The purpose of this research was to determine the effect of social media on eating disorder prevalence in college students. A raw data set of 500 survey responses with corresponding Eating Attitudes Test (EAT-40) scores was sourced and then analyzed within this research project. The methods included sourcing, sorting, translating, and then analyzing data through the data mining process to test the research hypothesis. Two kinds of analyses were run within the raw data, one with different hours on social media, and the other with different types of social media and their effect on eating disorder prevalence. Within analysis of hours spent on social media there were EAT-40 score means of 13.811, 12.052, 12.252, 13.663, 12.8, 13.5, 19.62, 13.4, 11.0, 11.5, and 18.333 and within the analysis of types of social media on eating disorder prevalence there was EAT-40 score means of 13.298, 12.571, 14, and 13.593 (an EAT-40 score of 20 or above is at high risk). With both sets of analyses to test the null hypothesis, a Single-factor ANOVA was used while maintaining an alpha value of .05. The p-value for hours was .062, and for types of social media it was .554 meaning the research hypothesis predicted that higher hours and Instagram would increase

EAT-40 scores, was not supported. This study helps us to find patterns between daily habits and eating disorder tendencies so that we can prevent eating disorders entirely.

Third Place

Emma Stone -The Correlation Between Personality Type and Academic Achievement
Central Virginia Governor's School for Science and Technology

The purpose of this experiment was to examine the correlation between personality type and academic achievement. This study was conducted using students aged 15-18 from two local high schools in Virginia. Recruited high school students were required to fill out consent forms and, once completed, they received a survey. The survey included questions from the "Big Five Personality Test," along with other questions that tested levels of academic achievement. The academic achievement questions tested grade point average, club participation, emphasis on school importance, and motivation levels. After the surveys were returned and completed, a correlational statistical test was run between conscientiousness and openness levels and academic factors. With an alpha value of .05, and an r-critical value of .367, the data output revealed a significant correlation between personality type and academic achievement. There was a correlation between two groups: conscientiousness and motivation, and openness and club participation. After these results, two linear regression tests (alpha .05) revealed that conscientiousness had a relationship to motivation, with the p-value of the regression test being 1.54×10^{-19} . Also, motivation had a relationship with club participation, with a p-value of 4.01×10^{-9} . Despite the correlation and predictive relationships found, the research hypothesis was not supported by these data. This study supported that personality type does have a correlation with factors of academic achievement, however academic achievement as a whole is not directly correlated with personality types.

Third Place

Annie Yuan - Emotional Perception of Vaping Affects Vascular Health of Electronic Cigarette Users
Mills E Godwin High School

While electronic cigarettes (e-cigarettes) have gained significant popularity in recent years due to being marketed as a safer alternative to traditional cigarettes, the long-term effects of vaping on chronic e-cigarette users are largely unknown. This study aims to investigate whether e-cigarette users' emotional perception of vaping affects their macrovascular health. Thirty-seven e-cigarette users participated in this study and responded to the Short-Form Vaping Consequences Questionnaire

(S-VCQ). Additionally, participants' macrovascular health and endothelial function was measured through flow-mediated dilation (FMD). Data was then analyzed using independent sample t-tests at a critical value of 0.05. It was found that participants who reported that vaping helped them deal with anger, anxiety, or worry exhibited significantly lower FMD results and thus lower brachial artery dilation during hyperemia than participants who did not feel similar emotional benefits from vaping. However, participants with anxiety overall did not have different FMD than participants with no anxiety, implying that using vaping as a coping mechanism decreases vascular health. As impaired vasodilation is linked to future cardiovascular disease, further research should be conducted on the specific physiological effects of vaping on e-cigarette users' vascular health coupled with their emotional perception of vaping.

Bisan Rai - Online "Group" Effect on Addiction Recovery
Southwest Virginia Governor's School

Addiction is among the leading factors in deaths under the age of 45 all across America. According to the NCDAS, "Over 70,000 drug overdose deaths occur in the US annually" (2023). One very popular alternate method of treating addiction is group therapy and exposure. However, some experts conflict on its effectiveness. With the increase in online spaces that help connect millions across the globe, people suffering from substance use disorder can find websites to help them overcome their addiction online. One such website is the International Quit and Recovery Registry, (IQRR; quitandrecover.org) which was built for the goal to help others in addiction recovery by providing information and help all in one website. The question being discussed is "How does the registry members' self-reported 'group' experience of the International Quit & Recovery Registry (IQRR) affect their success in addiction recovery?" To figure out this question, data was collected from the 2023 IQRR November Monthly Assessment. The data collected for the experiment was the participant's remission status based on the DSM-V, the proposed "group" experience responses, and other demographics. The following data was compared in a Chi-Square test of homogeneity. The results were found insignificant but that doesn't mean that the "group" experience had no impact on the participants' recovery journey. The statistical analysis only took into account one single monthly assessment. Further researchers should take into account other variables than just remission status and conduct the experiment over multiple months to gauge a better understanding of the problem.

Lainey Woody -The Effect of Music on Testing Anxiety
Central Virginia Governor's School for Science and Technology

The purpose of this research was to understand if different types of music can be used as a way for teenagers to cope with anxiety during times of heightened stressful situations in the academic environment, for example, testing. To conduct this research, students were asked to take a math quiz in a testing environment while listening to different types of music (Pop, classical, and no music). After each quiz with the different variables, they then took a ranking style anxiety symptoms survey that was later added up for each participant's anxiety score per type of music they tested with, in the three-week period. That data was put into an ANOVA: Single Factor test that resulted in a p-value of .136 which was higher than the alpha value of .05. This concluded that the data show no significant difference between students' anxiety symptoms and the type of music played while testing. The research hypothesis that stated, "If a high school junior, who is enrolled in pre-calculus, listens to classical music while taking a math quiz in an academic setting, then the anxiety symptoms of the students will decrease compared to the anxiety symptoms while taking a math quiz with pop or no music," was not supported by the results. In conclusion, different types of music had no significant effect on lowering the testing anxiety symptoms of students.

Mitchel Wait – Cognitive Memory as it Relates to Sound
Southwest Virginia Governor's School

In a classroom or learning setting, there are many different factors that can affect the way that students learn and how well they can comprehend the material. Sound is considered to be one of the most, if not the most, temperamental of these factors and can completely determine if any information is retained at all during learning. Sounds can also recall childhood memories and create a feeling of nostalgia. However, there have been minimal studies on how sounds affect human memory, and if these sounds can recall specific pieces of information and enhance learning. Four groups of five students were taken to a room at different times. Each group had different sound conditions. Once each group had been given a presentation on the information, they were asked to take a test on the same information. Each group's test scores were taken, and the mean was calculated for each group. Group three had the highest score, with an average of 72%, and group one and four had the lowest score, with an average of 58%. An ANOVA test was used to determine if the scores were statistically significant from each other. The test gave a p-value of 0.4452, implying that there is no significant difference between the groups. A Tukey test was then run to gather more specific evidence. This test showed that there is no significant difference between any of the groups, with the lowest p-value of 0.5481 between group one and group three. While not statistically significant, the results of this test have some interesting implications. The group with the pleasant sound did have a higher mean test score

than group one, with no sound. In addition, the group with the unpleasant sound had the exact same mean score as the group with no sound at all, implying that the brain is able to block out certain sounds and work with the same efficiency. This also implies that the pleasant sound could make a difference in effectiveness, or it makes it easier to focus and pay attention while learning. Future studies could be done where the information is learned over a period of time with the noise and the test is done on another day, as the information in this test was not given time to transfer to long term memory.

Sophie Perdue – Comfort Level Discussing Medical Topics Based on Parental Education Level

Southwest Virginia Governor's School

It is important to understand more about the willingness that teenagers have to speak to others about controversial health subjects. Many studies have been conducted to evaluate differences in adults' opinions, but few studies have been conducted about teenagers' comfort level. These questions led to the proposed hypothesis: a parent's education level does affect how comfortable a child feels discussing medical topics. The goal of this study was to examine whether there were differences in comfort level based on parental education level. The data were collected through a survey created by the student researcher. After returning the Human Informed Consent Form, participants were instructed to indicate their comfort level discussing controversial medical topics, such as abortion, on a Likert scale ranging from 1 to 5. In total, 78 surveys were returned and tabulated, offering participants choices for the highest level of education either of the parents had completed. Once all data were collected and recorded, the student researcher used JMP to perform a Chi-squared test of Independence to analyze the data. The analysis resulted in all significant p-values, ranging from <0.0001 to 0.0092 . The result of having all significant p-values suggested that the more education a parent in the household has, the more likely their child is to discuss sensitive medical topics. While the null hypothesis was rejected, more research still needs to be done to fully evaluate and examine the potential differences between teenagers' comfort level based on parental education level. In addition to parental education, other factors should be considered in future research, such as a parent's race, socioeconomic status, or career.

Scarlett Smith -The correlation between maternal cosmetic use and their teenage child's confidence.

Central Virginia Governor's School for Science and Technology

The purpose of this experiment was to determine the correlation between maternal cosmetic use and their teenage child's confidence. The procedure for this experiment included recruitment of participants from local high schools (and their corresponding mothers), who were to fill out a questionnaire. This consisted of questions pertaining to their self-confidence and makeup use (Pre-verified from The Harrill Self-Esteem Inventory). Once the data was collected, it was then organized into a master spreadsheet to be analyzed. Linear regression and correlation tests were run in Excel. The regression test resulted in a p-value of .177, which is higher than the chosen alpha value of .05. This means that the research hypothesis was in fact not supported by the data. The data did however show correlation between maternal makeup use and their child's confidence (r value of -.237 compared to critical value of .221). While this experiment did not conclude that there was a direct and independent relationship between the two variables, it did show the possibility for there to be a stronger correlation if tested again. This means that there is a potential relationship between the cosmetic industry and the mental health of our youth.

SAI - Statistical Analysis and Inferences

First Place

Sriyutha Morishetty - An Empirical Analysis of the Existence of Greenwashing in the Wider US Market: A Test on the Efficacy of ESG Scores

Individual

The purpose of this study was to investigate the relationship between a company's Environmental, Social, and Governance Score (ESG Score), a widely accepted method of a firm's perceived environmental sustainability, and each firm's corresponding greenhouse gas emissions. This provides an empirical analysis of the existence of greenwashing in the stock market as well as the effectiveness of ESG scores as a reliable market tool. Using S&P Global ESG Scores and Trucost Environmental data from Wharton Research Data Services database, linear univariate, multivariate, and fixed effect regression models were employed to derive the relationship between a company's average annual ESG score and the natural log of a company's annual greenhouse gas emissions cost. It was hypothesized that there would exist a strong negative correlation between a firm's ESG score and greenhouse gas emissions cost, as a company with worse environmental policies would have a greater cost associated with negative emissions. However, there existed a weak positive correlation between a firm's ESG score and greenhouse gas emissions, indicating that a firm's overall ESG score does not well-represent a company's negative greenhouse gas emissions. In order to more comprehensively evaluate the sustainability of a firm, a more expansive

variety of company-assessing tools and indexes should be taken into consideration, as a firm's overall ESG scores does not thoroughly assess every portion of a firm's environmental policies. This calls for improved mechanisms of measuring the environmental impact of a firm in order to encompass the full effect of negative emissions in a company's environmental rating and diminish the existence of greenwashing in the wider US market.

Second Place

Abhijit Somala - Predictive Wildfire Modeling in California: Leveraging Machine Learning for Effective Resource Allocation and Prevention Strategies

Individual

The paper explores the threat of wildfires in California (CA) and uses a novel technology known as Machine Learning (ML) to prevent this disaster in the long term, especially considering the increasing risk of wildfires in the past 21st century. The study addresses the research gap in predicting wildfires in CA and provides a comprehensive discussion of the performance of the ML model as well as the implications of the results. More specifically, it emphasizes the implications associated with the prevention of wildfires. The study was conducted by training the model with 50,000 samples (80% of the total data collected) and testing the model with 10,000 samples (20%), which ultimately resulted in an accuracy rate of 94%. The data was collected from three primary sources: NASA satellite data, the University of CA, Berkeley, and the CA Forestry and Wildfire Protection Department, which served to train and test the model. The model's accuracy proves the viability of this research to be applied in a larger context and to future research due to its high accuracy rate. This research emphasizes its potential to be applied to effectively allocate resources, especially in areas where wildfires often occur, which is vital to conserve and protect natural resources as well as optimize the allocation of human resources. In addition, further improvement can be made by incorporating a larger study area. The paper concludes by offering vital advice for future collaboration to gain more data and continuous refinement of the model due to the volatile nature of the environment.

Keywords: wildfires, environment, machine learning, predictive model

Third Place

Lily Brame - An Analysis of Gender Equality and National Success: Are You Happy, Healthy, and Wealthy?

Chesapeake Bay Governor's School

Understanding the effects of gender equality on societies can help us understand how nations thrive throughout history. The emphasis on gender roles can affect the system

within a country. Assessing the role of women in various nations aids progress in changing how gender equality is addressed. Research was conducted by analyzing a ranking of gender equality across the globe. The world population review was used to find the top ten, middle ten, and least ten equal countries in relation to gender equality based on a gender gap index (GGI) of that country. The parameters of happiness, healthiness, and wealthiness were each individually chosen as a means of assessing the overall success of a country. The results for these parameters, which were happiness ranking, population, life expectancy, air pollution, birth rate, and years of school, had a significant correlation with $P < 0.05$. The results for unintentional poisoning deaths, GDP, and unemployment came out with a P value greater than 0.05, making them insignificant. Six out of nine parameters provided a significant correlation indicating that the gender gap index of a country has an effect on the parameters of success for a country. Happiness and health are directly correlated with gender equality. Promoting gender equality will promote prosperity. The success of women is a determining factor for the success of a country. The entirety of the data supports the idea that gender equality will positively impact health and happiness, but it has no impact on the wealth of a country.

Honorable Mention

Jonathan Herrick - Relationship Between Economic Inflation and Stock Performance
Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if there was a relationship between the economic inflation rate and the performance of the US stock market during periods of economic stability. This study was conducted by collecting sets of data from Investing.com and the U.S. Bureau of Labor Statistics and then using Microsoft Excel statistical testing programs to analyze the data sets. The energy, information technology, and industrial sectors of the stock market with mean values of \$658.922, \$426.078, and \$541.241, respectively, were compared to economic inflation rates with a mean rate of 1.56% between 2009 and 2018 by conducting three correlation tests with a critical value of .194. Additionally, three regression tests with an alpha value of .05 produced p-values of .000197 (Energy Sector), .007 (Information Technology Sector), and .01 (Industrial Sector). Each of these were statistically significant and supported the research hypothesis that there would be a positive relationship between rates of inflation and the performance of the stock market. The conclusion drawn from the study was that the economic inflation rate positively affects the performance of the stock market.

Honorable Mention

Isabella Liu -The Impact Comparison of Artificial Intelligence on Different Occupations in the Labor Market

Blacksburg High School

With rapid development, artificial intelligence (AI) not only provides people with great convenience, but partly replaces human resource work and generates considerable concerns in the labor market. Although repetitive low-skilled jobs are considered to be substituted first by AI, the emergence of ChatGPT, AI painting, and other new technologies suggests that high-skilled jobs are also at risk of being replaced. This study argues that considering the various work content and nature of each industry, AI has different uses and impacts on different industries; in some businesses, AI may even provide more existing and new job opportunities in the labor market, which leads to inequality across industries. This study identifies the potential pattern for AI effects on various industries by analyzing relevant data from the US Bureau of Labor Statistics and International Labor Organization. This study will explore various industries based on the International Classification of Occupations' classification, comparing the impact of AI on different industries from aspects such as unemployment rate, salary, and changes in human job skills. The focus of this study is to define the gap between the impact of artificial intelligence on employment in various industries. This study also proposed some solutions to solve the gap by analyzing the differences in impact. By identifying which industries are most negatively affected by artificial intelligence and which industries benefit the most from artificial intelligence, governments and related agencies can better make policies and aid to safeguard the interests of the former and limit the latter's access to excessive resources. Doing so can address industry inequalities and create a better society where AI exists.

Honorable Mention

Lishu Wang - The Economic Impact of California's Recent Out-Migration on its Neighboring States

Blacksburg High School

Recently, many people have been moving out of California, a state known for its striking politics, often ominous climate, and high taxes. Mostly, these ex-Californians have been going to nearby states, hoping to find better opportunities there. The entry of great numbers of people into specific areas often has a great effect on the economic state of such areas. In this paper, the impact of California's massive out-migration on California's border states' economies was examined. Correlational studies of the counties of each of these 3 border states— Arizona, Nevada, and Oregon— were done, examining the effect of the number of movers coming from California on the change in

real Gross Domestic Product (GDP) for each county between the years 2014 and 2018. It was found that the movement of Californians into California's bordering states was associated with positive GDP growth in these bordering states, though whether this movement of people was the only factor contributing to the GDP increase is quite dubious, as the link between mover counts and changes in GDP was limited. The conducting of further studies on the impact of California's leaving population on recipients of this population would greatly strengthen the implications of the results produced in this study.

Isaac Hardin -The Effect of Fine Arts Involvement on Academic Performance
Central Virginia Governor's School for Science and Technology

This research study was conducted to examine if a correlation exists between involvement in fine arts programs and improved academic performance. Since this was a non-experimental study, only pre-existing raw data sets were used and no new data was collected. The main raw data set used for this study was seven years of SAT score reports. The total population average scores and average scores from students intending to major in Visual & Performing Arts in college from all seven years were tested using a two-sample t-test assuming equal variances. That t-test returned a p value of .579, which when compared to an alpha value of .05, showed no statistically significant difference between fine arts involvement and improved academic performance. This result did not support the research hypothesis, which was that fine arts involvement would have a statistically significant positive effect on academic performance. There were some challenges encountered during the process of collecting data sets for this study, which could have had an impact on the results. Additionally, the results of this study did not reflect the results of similar studies. The inspiration for this study was attempting to find a reason for schools to support fine arts programs because of their potential benefit to academics, but the results did not show that potential benefit.

Griffin Quinones-Partain - Correlation Between a Country's GDP and Secondary Aluminum Production
Central Virginia Governor's School for Science and Technology

The purpose of this study was to discover if there was a correlation between the amount of secondary aluminum a country produced and its GDP (gross domestic product is often used to measure the economic well-being of a country) over the course of 10 years. The study was done using data found from reliable organizations and sorted into a spreadsheet on a computer. The data from three different countries (China, the United States, and India) was used in this study. Correlation tests analyzing each country's

secondary aluminum to GDP relationship revealed r-values of .8542, -.28884, and -.4875. Compared to a critical correlation value of .632, only China showed a significant correlation. Because only one test showed a statistical significance, the hypothesis was only partially supported. In most cases, the study revealed that there was no correlation between the amount of secondary aluminum a country produced and its GDP.

Parker Sittason - Comparing the Frequency of Knee Injuries in American Football on Artificial Turf Vs Natural Grass

Central Virginia Governor's School for Science and Technology

The purpose of this study was to determine if there was a correlation between NFL athletes playing on artificial turf and increased risk of knee injury. The study was conducted primarily at Central Virginia Governor's School, using a school provided computer, to analyze the NFL's injury database. 3 NFL seasons were examined (2020, 2021, 2022), wherein every knee injury throughout this period was identified along with the field type on which they occurred. The total injuries on both natural grass and artificial turf per season, were collected, and ran through a t-Test: Two-Sample Assuming Equal Variances. The average incidences of knee injuries on turf fields over the three-year period was 156.66 per year, whereas the incidences of knee injuries on grass fields averaged 167 per year. The t-Test revealed a p-value of .46 which when compared to an alpha value of .05, found the data to not be statistically significant. Since the data was not statistically significant it did not support the hypothesis, if football players play on artificial turf fields rather than grass fields, then their possibility of having knee related injuries would increase by 15%. In conclusion, playing on artificial turf had no significant effect on athletes' risk of knee injury.

Jenna Burks - Predicting Familial Relationships Using Fingerprints

Central Virginia Governor's School for Science and Technology

The purpose of this research was to explore the connections within fingerprints using a simple and low-technology approach. The study involved participants from local schools, including students of different ages and adults. The participants were divided into pairs consisting of mothers and their daughters. Fingerprints were collected from the right hand of each individual. The fingerprints that were collected were assigned a score depending on the number of shared characteristics they possessed. The data was then analyzed using a t-test assuming equal variances. The average score for the related pairs was found to be 10.43, while the unrelated pairs had an average score of 8.86. Conducting a t-test assuming equal variances with an alpha value of 0.05 resulted in a p-value of 0.645. This p-value, which is statistically insignificant, does not support

the research hypothesis that fingerprints taken from mother-daughter pairs would exhibit more similarities compared to unrelated pairs.

Ryan Chen -The Effect of Different Brands of Competitive Swimwear on the Amount of Water Absorbed
Clover Hill High School

The purpose of this experiment was to determine the effect of different brands of competitive swimwear on the amount of water absorbed, in order to discover the most hydrodynamic swimsuit for competitive use. The research hypothesis stated that if the swimsuits were submerged in a 1 part per million (ppm) chlorine solution for 1 hour, the swimsuit from the Arena brand would absorb the least amount of water. The chlorine solution was prepared using serial dilutions. Thirty trials were conducted for each brand of swimsuit: Arena, Speedo, and Dolfin. Each swimsuit was weighed and submerged into the chlorine solution, and the final weight was taken an hour later. The initial mass was subtracted from the final mass of the swimsuits to receive the total amount of water absorbed, in grams. The data was analyzed using a One-Way ANOVA test to determine if the results were statistically significant. The ANOVA test rejected the null hypothesis of no significance. The results concluded that the Arena suit absorbed the least amount of water with an average absorption of 49.87 grams, followed by the Dolfin suit with 54.38 grams, and the Speedo suit with 69.27 grams. The research hypothesis was supported by the experimental data because the Arena swimsuit absorbed the least amount of water in comparison to the Dolfin and Speedo suits.

Tripp Walker - How Has 1930's Redlining Affected the Current Equity of Walkability in American Cities?
Chesapeake Bay Governor's School

Throughout the 1930s in New Deal America, a prominent example of systemic discrimination occurred with the implementation of redlining in American cities by the Homeowner's Loan Corporation (HOLC). Redlining was an endemic factor in the design period in many major American cities, and D-ranked neighborhoods became the only areas where low-income families were able to settle reliably. Through metadata analysis of city maps, data can be collected to determine these differences and used to further promote improvement for previously redlined communities. Six urban sites in the United States were chosen for analysis based on their similar population size (~200,000), history of red-lining, and relative proximity to one another on the east coast: Richmond, VA; Norfolk, VA; Lexington, KY; Pittsburgh, PA; Greensboro, NC; and Springfield, IL. In each city, 30 data points were collected in A-rank and D-rank neighborhoods for

distance to greenspace, distance to public transport, distance to major highways, Walk Score, Transit Score, and Bike Score for comparison. All three distance-based comparisons yielded statistically significant t-test, $p < 0.05$; however, all three score-based comparisons failed to yield statistically significant t-test, $p < 0.05$. Redlining has influenced the design of many of America's modern-day cities with discriminatory intentions that continue to promote inequality in health, reduced access to necessities, and diminished quality of life today for affected communities; however, city design can still be improved to reduce the differences in equity between low-income and high-income neighborhoods. In order to make cities more equal for all residents, moving towards implementation of high quality and accessible infrastructure that is walkable and green in redlined communities is the best option.

ZOO - Zoology - A

First Place

Ailin Harpole - Assessing Reproductive Substrate Availability and Timing for *Chrysaora chesapeakei*
Chesapeake Bay Governor's School

Most micro-organisms of the Chesapeake Bay start in a planktonic state and are susceptible to the constantly changing coastal estuarine environments, especially in their juvenile stages. *Chrysaora* Jellyfish reproduce through broadcast spawning events in the water column, creating swimming planula larvae who then have to find a suitable hard substrate, like oyster shells, to attach themselves to. Competition with fouling organisms like barnacles and tunicate over substrate space causes population control for jellyfish scyphistoma. Without proper clean space for settlement *Chrysaora chesapeakei* cannot reproduce properly. Five sites with docks were identified along the tributaries of the lower Chesapeake Bay. Larval collectors were constructed similar to spat collectors used for oysters. Three downturned oyster shells were tied onto a string, at their center of mass, that would hang vertically, one resting at the bottom, one in the middle, and one sitting at the top of the water column. Over the course of 10 weeks, Hallieford showed significant increases from week to week of scyphistoma coverage on shell. Starting in July the average scyphistoma coverage across shells at each site steadily increased before leveling off in September for Hallieford. Scyphistoma polyps were found at four out of the five sites at the end of the study period, but Port Haywood showed no signs of jellyfish reproduction and tied for the least amount of fouling on a determined index. The results for this study are important because it outlines the environmental factors that are best suited to jellyfish reproduction.

Second Place

Aditya Badhrayan -The Effect of Intermittent Metabolic Switching on a-synuclei aggregation in Parkinson's Disease via *Drosophila melanogaster*.

Individual

Parkinson's Disease is a highly prevalent neurological disorder that affects the Central Nervous System. A primary biomarker for the disease that has been recently discovered is the aggregation of a-synuclein proteins in neurons. However, there is no definitive treatment to help ameliorate Parkinson's. This project used the *Drosophila melanogaster* (fruit fly) model of Parkinson's to analyze whether ketosis induced by Intermittent Metabolic Switching can help reduce locomotion disorders due to alpha-synuclein aggregation. Methods: Transgenically mutated flies with SNCA gene were used to model the disease. Flies were placed under a high fat-low carbohydrate diet and placed under a 14-hour fasting and 10 hour feeding period for four days. Locomotion was analyzed using the negative geotaxis assay. The data was analyzed using ANOVA and chi-square tests. The results demonstrated that locomotion was significantly increased through induced ketosis. Meanwhile, the diet had no effect on the flies without a mutation, demonstrating that induced ketosis played a role in ameliorating symptoms relating to Parkinson's Disease caused by the aggregation of a-synuclein. Conclusion: Intermittent Metabolic Switching is a crucial intervention in Parkinson patients. Further pathological interactions should be studied.

Third Place

Neha Beeravalli -The Effect of Tempo Speed Vibrations on *Daphnia magna* Heart Rate
Mills E Godwin High School

The experiment aims to explore the impact of tempo speed vibrations on the heart rate of *Daphnia magna*. The purpose of this experiment is to understand how external stimuli, such as rhythmic vibrations, influences the physiological response of these organisms. It is hypothesized if the metronome is set to 1000 bpm, then the heart rate of *Daphnia magna* will increase. This prediction is based on the assumption that the rapid tempo will stimulate a response in the organism, leading to an elevated heart rate compared to a control group subjected to a different to no tempo. This research contributes to a broader understanding of how environmental factors, including noise pollution, can impact the cardiovascular functions of aquatic species, with complications on ecosystem health and biodiversity. A metronome was used, and a subwoofer was positioned beneath the *Daphnia*. The metronome was set to the desired beats per minute (100 bpm, 300 bpm, 600 bpm, 1000 bpm) for a 10-minute duration. After, *D. Magna*'s heart rate was observed under a dissecting microscope. The results show that tempo speed vibrations have a statistically significant effect on the heart rate of *Daphnia magna*. The t-test results for all comparisons between the different speeds and the control revealed that the null

hypothesis was rejected, supporting the research hypothesis that 1000 beats per minute leads to an increase in the *Daphnia magna*'s heart rate compared to other tempo levels and the control.

Honorable Mention

Kristine Edassery -The Effect of Household Beauty Products on *Daphnia magna*
Mills E Godwin High School

Water quality is directly negatively impacted by sewage treatment plants. Even when treated, many chemicals get overlooked or filtered out incorrectly. This sewage comes from many places, such as the drains in our own houses, where many things are poured down- including beauty products, which contain chemicals harmful to aquatic life, such as phthalates and parabens. The purpose of this experiment is to test the effect of household beauty products on *Daphnia magna*, their heart rates in particular. The hypothesis states that if one mL of hairspray per 100 mL of water is added to the environment of the *D. magna*, then their heart rates will increase more than if perfume or shampoo was added, or if there was just plain water. The levels of independent variable- perfume, shampoo, hairspray, and plain water were added to the environment the *D. magna* were living in (plain water was the control), and their heart rate (in bpm) was recorded after ten minutes using a microscope, pen, paper, and a timer set for one minute. This was duplicated 24 more times with each level of the independent variable. The results showed that the beauty products did not increase the heart rates of the *D. magna*, but rather it was lowered, but there was still a negative effect, nonetheless. Opposing the hypothesis, perfume had the greatest effect on heart rate, and hairspray had the lowest. The standard deviation values implied that the data was loose, and overall, the data was significant.

Honorable Mention

Peter Appleton -The Effect of Various Household Chemicals, when Used as a Deterrent, on Food-Gathering Speed in *Pogonomyrmex occidentalis*
Clover Hill High School

Ants' usage of pheromone trails has catapulted them into status as the most prevalent pests in nearly every form of building. These pheromone trails are challenging to counter, requiring diligent efforts and the combined usage of sanitation and mechanical methods. However, chemical control methods have emerged as an effective method to counter ant proliferation. The research hypothesis was that *Pogonomyrmex occidentalis* would take a longer period of time to collect food from food sources when the path is subjected to vinegar due to its uniquely high acidity and strong odor. Vinegar, bleach, bug spray, air

freshener, and hand sanitizer were tested in the experiment, with no chemical interference as the control, each sprayed upon an ant's trail from their colony to the nearby food source of a mango slice. The ants were given 15 minutes to gather food without chemical interference, then 15 minutes with chemical interference—this allowed for the ants to determine the location of a food source, establish a pheromone trail, then allow the experimenter to observe the effects that the given chemical had on their food gathering process. The results displayed that air freshener and bug spray were most effective in deterring ants. Vinegar and the control had little effect as ant deterrents. An ANOVA test was conducted to determine statistical significance, and the results were proven statistically significant. The null hypothesis was rejected. The research hypothesis was also rejected, since vinegar was not the most effective deterrent. The results show that common household products can display effectiveness in ant deterrence, but those that are more odorous like bug spray and air freshener were far more effective than other household products.

Honorable Mention

Ishaan Atturu - The Effect of Solvents on Oil Removal from a Feather

Mills E Godwin High School

The purpose of this study was to determine which solvent was the most effective in removing oil off a feather. Oil spills are released in a multitude of ways, but discharges leading to the formation of oil sheens are the most common. Oil sheens are hydrocarbon concentrations in water that are extremely small, as opposed to oil slicks which are substantially bigger. They take the lives of over 500,000 birds each year. The hypothesis was if Dawn Dish Soap was applied to the feather, then there would be the most oil removal. Dawn Dish Soap was the control of this experiment as it was widely considered to be the most efficient oil. There were two tests, one for weight and one for hydrophobicity. The feather was dipped in oil and had its weight checked, then was cleaned with the solvent being applied to it. The hydrophobicity test was found by observing whether it floated or sunk. A t - test was conducted for weight, showing varying results for each level of IV. A chi - square was conducted for hydrophobicity, also showing varying results for each level of IV. Dawn Dish Soap showed the most positive results in the experiment, proving that it is the best solvent for cleaning oil of a feather. It was the only solvent that completely removed the oil of the feather (got to 0 grams) and had all its feathers float. Future research suggests that taking different climates into consideration when dealing with oiled feathers.

Lily Branch -The Effect of Melatonin on Regeneration of *Dugesia dorotocephala*
Central Virginia Governor's School for Science and Technology

The purpose of this study was to explore the relationship between melatonin and regeneration. This study was conducted in a high school laboratory during the fall of 2023. *Dugesia dorotocephala*, commonly known as planaria, was used to test the concept. Each planarian was bisected horizontally and placed into separate well plates, which contained one of three different melatonin concentrations (0.0 mmol dm^{-3} , $0.05 \text{ mmol dm}^{-3}$, and 0.1 mmol dm^{-3}). Over a two-week period, the length of each test subject was measured three times and the overall, week one, and week two changes in growth were calculated. These overall means of growth were .069 (control), .072 ($0.05 \text{ mmol dm}^{-3}$), and .07 (0.1 mmol dm^{-3}). To analyze the data, an ANOVA test produced p-values that were compared to the given alpha value of .05. The p-value for the overall growth was .998, week one was .761, and week two was .248, all of which were higher than that of the alpha. The research hypothesis which predicted that the planarian treated with highest and lowest concentrations of melatonin would have a lower rate of regeneration, was not accepted. To conclude, this study shows that there is no statistically significant difference between planarian regeneration amounts when they were exposed to different melatonin concentrations.

Rimil Chatterjee -The Effect of Various Amounts of an Ascorbic Acid Solution on the Difference in Length of *Dugesia dorotocephala*
Mills E Godwin High School

The purpose of this experiment was to determine the effects of various amounts of an ascorbic acid solution on the difference in length of planarians, model organisms that can rapidly regenerate tissue. Recently, people commonly search for better remedies, such as natural vitamins and minerals, for their wounds than prescription drugs with possibly dangerous side effects. Regeneration in planarians was measured after they were exposed to various amounts of an ascorbic acid solution for an amount of time. The control was a group of planarians that were not exposed to any of the ascorbic acid. It was hypothesized that the planarians exposed to 6 mL of the ascorbic acid solution would have the largest difference in length. The results of the experiment showed that the planarians in the control group had the largest difference in length compared to the other experimental groups. Multiple t-tests were performed on the data, and it was found to be statistically significant for all the experimental groups except for the planarians exposed to the 2 mL versus the 4 mL of ascorbic acid solution. The observed results did not support the research hypothesis. It is speculated that the results are due to the rapid decomposition of ascorbic acid in water and the reduced pH of the 6 mL independent variable and the planarians' inability to compensate for the lowered pH even with their

internal mucus. This experiment could lead to further investigations into other vitamins and medications and their effects on the regeneration of planarians.

Bryce Croxford -The Effect of Food Dyes on Planarian Growth
Mills E Godwin High School

The purpose of the experiment was to determine the effect of food dyes on planarian growth. This is because food dyes are extremely prevalent in modern foods, and there are concerns about the health of consuming food dyes. A hypothesis was formulated that there would be a significant difference between the growth of planaria when exposed to Red 40. Planaria were placed in Petri dishes and fed 0.2mL of egg yolk that had been blended with 5 drops of each IV. The control of the experiment was egg yolk without any added food coloring. The results of the experiment indicated that the control group experienced more growth than the other IV levels. Red 40 experienced the second highest growth with a 2.1mg difference in mass and the Yellow 5 group experienced the least, at 1.5mg. Furthermore, a t-test was conducted on the data to determine whether or not the data was statistically significant. The t-test indicated that the experiment was not statistically significant except for Yellow 5 and Yellow 6. These results reveal that the research hypothesis was not supported. The results of the experiment indicate that there are no adverse effects on the consumption of large amounts of food dyes. The results are believed to be the result of a short experimentation period. For further experimentation, the time of growth should be expanded upon. Furthermore, an alternative method to measure growth can be used.

Ayan Jethava The Effect of Indian Medicinal Spices on Planarian Regeneration
Mills E Godwin High School

This experiment was performed with the purpose of studying the effects of common medicinal spices on the regeneration rate of planaria. Traditional practices of medicine have utilized the use of natural remedies such as herbs and spices to aid in the management of various health issues for thousands of years. Planaria have somewhat similar stem cell function as humans meaning that enhanced regeneration in planaria caused by medicinal spices could translate over to enhanced recovery in humans. One hundred planaria were treated with 20 mL of different solutions of turmeric, cardamom, and coriander. Water was used as a control group. The time it took for the planaria to fully regenerate was recorded in days. It was hypothesized that if planaria was exposed to turmeric, it would regenerate at a faster rate. On average, the planaria treated with turmeric regenerated four days faster than the control group. The data of all comparisons with the exception of Cardamom vs. Coriander was statistically significant. The results of

the experiment supported the initial research hypothesis. Planaria regenerated faster in turmeric compared to the other IV levels because of the presence of a compound called curcumin. Curcumin enhances cellular processes and recovery. The curcumin within turmeric enhanced cellular processes in the pluripotent stem cells which are responsible for regeneration in planaria resulting in enhanced regeneration. For future study, the effects of varying concentrations of turmeric should be exposed to planaria.

Anika Kamujula -The Effect of Phenolic Acids on the Regeneration of *Dugesia dorotocephala* Cells
Mills E Godwin High School

The purpose of this experiment was to investigate how varying concentrations of phenolic acids would inhibit the regeneration and the regrowth of planaria cells. Several phenolic acids contain properties that allow them to directly combat the cell cycle and reproduction of cells. Stem cells can easily mutate into aggressive cancers. As such, understanding how phenolic acids impact stem cells would open more methods for controlling the spread of cancers. In the experiment, planaria, which are primarily composed of stem cells, were cut by 2 mm on the posterior end, exposed to various phenolic acids, and measured with a ruler to observe regenerated length. The levels of the independent variable consisted of 4% chlorogenic acid, 8% chlorogenic acid, 4% caffeic acid, and 8% caffeic acid, with the control group being natural spring water. It was hypothesized that if the planaria was exposed to the 8% concentration of caffeic acid, then the regenerated amount of planaria would be less than the control group. Observation of the means displayed the highest average regeneration in the Control group (0.9 mm) in comparison to other concentrations. Multiple t-tests were conducted, and it was found that most calculated values were slightly less than the derived t-value. The research hypothesis was supported by the results as the data displays that there is the least amount of regeneration when exposed to 8% Chlorogenic Acid. The results of this experiment can be taken further to investigate preventing stem cell production in humans and against active cancers.

Ethan Easter -Determining the Effects of Four Natural Items on Oranges to Repel *Drosophila melanogaster*
Southwest Virginia Governor's School

The *Drosophila melanogaster* is a species of fruit fly with a substantial history as a scientific research tool yet has little research on its inhibition within households where it is considered a pest. This is dangerous, as fruit flies can easily cause large amounts of fruit spoilage, negatively impacting both economics and agriculture. This experiment aimed to investigate four possible natural repellants: the extracts of *Mentha x piperita* (peppermint)

and *Ocimum basilicum* (basil), and the juices of Citrus x limon (lemon) and Citrus x aurantiifolia (lime). The repellants were applied to oranges one at a time and thirty flies were placed with the orange in a controlled environment. The number of flies on the treated orange was recorded every 5 minutes for 30 minutes, with each 5-minute interval being considered a trial. A Chi-Square Test of Homogeneity was done, along with an ANOVA test and a Tukey HSD test. The Chi-Square and ANOVA tests each reported a p-value of less than 0.0001, implying significantly different repellent effects. The Tukey test reported that the control and lemon-treated oranges were significantly different when compared to the peppermint, basil, or lime-treated oranges (p-value <0.0001). The average flies on each orange were 7.16 +/- 0.68, 8.83 +/- 0.81, 9.16 +/- 1.42, 23.8 +/- 0.27, and 25.6 +/- 0.149 for the basil, lime, peppermint, control, and lemon treated oranges, respectively. The results show that basil was a very effective repellent, alongside the lime and peppermint-treated oranges, while the lemon attracted more flies than the control. More research can be done with fruit fly repellants to develop natural repellant sprays or attractants.

ZOO - Zoology - B

First Place

Rania Lateef - Rhythms and Blues: Examining Potential Health Hazards of Blue Light-induced Circadian Disruption in *Drosophila melanogaster*
Governor's School @ Innovation Park

Background: Environmental disruption of circadian rhythms can have deleterious consequences for human health. The extent to which artificial blue light from LED lighting, smartphones and tablets affects circadian biology and mental and physical health outcomes is not well known. The main goals of this project were to study the effects of varying blue light exposure on *Drosophila melanogaster's* (1) lifespan, (2) memory (3) propensity to consume caffeine containing media and (4) gut permeability. Methods: Four experimental groups were used: controls, flies with the tim01 mutation, which eliminates circadian behavioral rhythms, flies exposed to 8 hours (BL8) and 12 hours (BL12) of blue (460 nm) light. To assess the effect on lifespan, the percentage of flies surviving over time, within each group, was calculated. Preference for caffeine containing food was evaluated using a constructed choice chamber where caffeine-enriched and regular media were presented to flies. Loss of intestinal barrier function was detected by the presence of a non-absorbable blue food dye outside of the digestive tract after feeding. The aversive phototoxic suppression assay was used to assess learning/memory; flies learned to avoid light that is paired with an aversive stimulus. Group differences were analyzed with survival curves, t-tests, and Chi-square tests as needed. Results: Control

flies lived significantly longer than the circadian mutants and flies exposed to blue light for 12 hours ($p < 0.001$). Circadian mutant flies demonstrated significant impairment in short-term memory and learning compared to the control flies ($P = 0.029$) as did the BL12 ($P = 0.009$) and BL8 ($P = 0.008$) groups. A preference for caffeine containing food, after 72 hours of exposure to it, was demonstrated by the circadian mutants (OR 10.52, $p < 0.0001$) as well as the BL12 (OR 6.07, $P < 0.0007$) and BL8 (OR 6.48, $P = 0.0003$) groups. More flies with *tim01* mutation and 12-hour exposure to blue light demonstrated impaired gut permeability compared to the controls. Conclusions: This study shows that prolonged exposure to blue light can cause increased mortality, impaired memory, propensity to substance use and accelerated gut aging similar to known circadian mutants; the degree and spectrum of effects may depend on duration of exposure. The health implications of a digital world require closer biologic scrutiny.

Second Place

Noah Poovathukaran -The Effect of Adaptogenic Herbs on Planaria Regeneration
Mills E Godwin High School

The experiment was conducted to determine if adaptogenic herbs influenced the regeneration time of planaria. Many individuals suffer from diseases related to the nervous system. These diseases are caused by the inefficiency of neurogenesis, the regeneration of neurons through stem cell activity. Neurogenesis can be replicated in organisms such as planarians, organisms known to regenerate damaged tissue. Moreover, different substances have also provided insight into a cure for neurodegenerative disease. Adaptogenic herbs, for example, such as Ashwagandha and Rhodiola have been used for centuries because of their neuroprotective effects. Thus, it was hypothesized that if a higher concentration of Ashwagandha or Rhodiola was used then the planarians would take fewer days to regenerate their head tissue. In this experiment, a control of spring water was used to compare the regeneration rates between variable levels. Before experimentation, solutions were created using liquid extracts of Ashwagandha and Rhodiola, and spring water. Solutions were divided between petri dishes and were based on the independent variable levels of Ashwagandha 0.1%, Rhodiola 0.1%, Ashwagandha 0.2%, Rhodiola 0.2%, Ashwagandha 0.3%, and Rhodiola 0.3%. Later, planarians were amputated and placed into the petri dishes; the regeneration time was recorded. According to the descriptive statistics test, the regeneration time decreased as the concentration increased in the adaptogenic herb solutions. In addition, the inferential statistics test showed that the data was statistically

significant. A reason for the results could have been that the substances promote stem cell activity and have neuroprotective effects.

Third Place

Manha Saleha, Aerin Kim, Alyssa Johnson -The Physiological Effects of Cumin as a Homeopathic Remedy for *Drosophila melanogaster*
Governor's School @ Innovation Park

Cystic Fibrosis is an autosomal recessive inherited disorder predominantly found in Caucasian populations. The disorder is the leading genetic disease that can cause fatality in the U.S. The mutation of the CFTR gene causes a dysfunctional channel which is unable to regulate chloride ion flow leading to increased mucus buildup in many of the body's major organs and pathways, including the digestive tract, an often-overlooked consequence of CF that can lead to undergrowth and malnutrition. Furthermore, infertility and increased levels of fatigue are common factors of a CF patient. The purpose of our experiment was to test cumin's ability to act as a homeopathic remedy to alleviate the previously mentioned symptoms in the model organism *Drosophila melanogaster* which was used due to its midgut being the equivalent of a human small intestine. 6 groups of *Drosophila* (- Mutant, + Acute Mutant, + Chronic Mutant, + Acute Wild type, - Wild type, + chronic wildtype) midguts' were dissected and stained with working MQAE solution, the midguts were then extracted and pinned down to the agarose petri dish by a minuten pin through their heads, midgut samples were then transferred to the centrifuge and later stained and observed under a mounted revolve scope and lastly fluorescent was detected under the Synergy Plate reader. Behavior Assays were determined by collecting 5 mutant male and females and counting their larvae output. Climbing Assays were determined by removing 20 flies and placing them in a 250mL glass graduated cylinder and counting how many flies were able to reach above the 190mL mark through recorded footage. Our data collected supported the hypothesis and we found that cumin concentration being incorporated into *Drosophila Melanogaster*'s diet resulted in higher MQAE levels meaning decreased chloride ion concentration and lower blocking of digestive tract, increased larvae output and increased endurance. These results in *Drosophila Melanogaster* can coincide with humans as implications of our research include a much cheaper more affordable homeopathic remedy to traditional highly expensive cystic fibrosis yearly treatments which range up to \$33,000 and can explain why Asian populations (Cumin is commonly incorporated into Asian diet) show lower rates of Cystic Fibrosis than populations that do not incorporate it into their diets

Honorable Mention

Grace Morton -The Effect of Feeding Plastic Polystyrene to Mealworms Compared to Baby Carrots on Survival Rate Over Time
Clover Hill High School

With the permanence of plastic pollution becoming a major issue for the environment in modern society, new solutions to reducing plastic waste are in high demand. This experiment set out to study the capability of yellow mealworms, *Tenebrio molitor*, to consume and digest polystyrene plastic. The hypothesis was that the more polystyrene (PS) introduced into the mealworms' diets, the lower the survival rate would be compared to that of the survival rate of mealworms on a diet of carrots. At the start of the study, two-hundred and forty mealworms were split into four groups of sixty. One group was fed purely PS, one purely carrots, one an equal ratio of PS and carrots, and the control group was given no additional nutrition. The experimental groups were all given the same quantity of food and were housed on wood shavings in a ventilated container. The experimental period lasted for thirty days, every other day the mealworms' food would be replaced and every three days the surviving mealworms would be counted (deceased mealworms were recorded and removed). At the end of the thirty-day period, it was found that the group fed carrots had the highest survival rate at 93.3%, followed by the group fed equal parts PS and carrots (73.3%), then the group fed only PS and the control group had the lowest survival rates at just 55%. The research hypothesis was supported by the data and the null hypothesis was rejected.

Honorable Mention

Kailin Phillips -The Effects of Age on Milk Fat Percentage in Holstein Cows
Southwest Virginia Governor's School

There is a wealth of knowledge about how milk fat in cattle changes relative to the age of the calf. However, few studies have been completed investigating how the cow's own age affects her milk fat production. The purpose here was to study whether young cows produce more milk fat than older cows. Research was done on eight Holstein cows, ranging in age from 2-5 years, with two cows belonging to each age group. Each cow had a similar birthdate to the other cow her age, they were 100% Holstein, and they had not been medicated six months prior. These cows were selected from Phillips Dairy Farm with the herd manager, and he collected and pasteurized samples. The sample collected from each cow was roughly the same in weight, with only a few grams of unavoidable difference. This did not impact the data because the ratio of milk fat was analyzed. To collect raw data, samples were left undisturbed and refrigerated for five days to allow the cream to separate. Each sample was then weighed whole, and the cream skimmed from each sample and weighed alone. This ratio (weight of milk fat/weight of whole sample) was analyzed by a bivariate linear regression analysis. A statistically significant correlation between cow age and milk fat production was not supported because of the low R-square value (0.077) and high p-value (0.5049). This refutes the alternate hypothesis and supports the null, showing no relationship between a Holstein cow's age

and milk fat production. This research question should be reexamined to see if a larger sample size using cows matched more closely in age and therefore weight would establish a significant correlation between age and milk fat. If another study was conducted that did find statistically significant results, it could mean that farmers would be better informed on when to breed their cows, and dairy processing facilities would not have to spend as much on additives as they could opt to use milk that is already ideal for each product (such as fattier milk from younger cows being used for butter).

Honorable Mention

Brett Smith - A Phylogenetic Analysis of the Origin of Neuronal Structures in Basal holozoan

Roanoke Valley Governor's School

The emergence of neurons and peptidergic cells in early Metazoa, and perhaps Holozoa, remains one of the largest mysteries of Metazoan evolution. Basal genes associated with neurons and peptidergic cell differentiation, messaging, and regulation are tracked down the two accepted phylogenetic models of early Holozoa to reveal gene lineages that possibly led to the emergence of neurons. NCBI's BLAST was used to locate fragments and homologs of accepted neuronal genes in Metazoa as well as in Choanoflagellates, the sister group of Metazoa. Isolated homologs were analyzed and searched for motifs that could potentially transcend neural function. Only longer sequences with very low E-Value were analyzed. Homologs of the neurosecretory SYNTAXIN1 protein isolated in Choanozoa by previous researchers were found in every phylum/infrakingdom of Metazoa, including Porifera and Ctenophora. Homologs of the iGlur gene Kainate 2 were represented in every Metazoan phylum except for Porifera. Homologs of SIFAmide neuropeptides previously isolated in Porifera were found also partially represented in Cnidaria and Ctenophora. Finally, homologous fragments of an axon guidance gene in *D. rerio* were found represented in all Metazoan phyla. Based on these results, it can be concluded that many cell-signaling and differentiation genes crucial to neurons developed before the diversification of neurons. The complexity of Ctenophore neurons likely developed predominantly separate from neural complexity in other animals. Ctenophore neurons were built from many of the same fundamental genes as Bilateria or Cnidaria. From these basic genes, other complex neural genes diverged in Bilateria, Cnidaria, and Ctenophora.

Ayaan Mohammed -The Effect of Electricity on the Regeneration of Planaria

Mills E Godwin High School

The purpose of this experiment was to find the effect of electricity on the regeneration of planaria. Regeneration is one of the most untamed fields in science, and planaria can

help provide a greater insight on how we can use various kinds of treatments to help our cells, given the similarity of planaria stem cells and human stem cells. There were four different IV groups with 25 planaria fragments being shocked at either 1V, 2V, or 3V, for 30 seconds. The length of each planaria was measured in centimeters after 14 days. The control that was used in this experiment had no voltage, results being a comparison to the other levels of IV. The hypothesis for the experiment stated that if the voltage was higher then the planarian regeneration will increase. Observations showed that higher voltages seemed to increase regeneration rate, with the planaria growing larger than those in the control group. This suggested that higher voltages increased the rate of regeneration of planaria. A t-test was performed, showing that all the data was statistically significant, which proved the research hypothesis. It is believed that the results are due to the field strength emitted by the voltage, where the higher voltages yielded a strong field strength, leading to faster proliferation rate of planaria stem cells. This research could lead to further studies that could investigate different ways to increase cell proliferation and understand how electricity can affect stem cells.

Heshan Molligoda -The Effect of Antibacterial Ointments on Planarian Regeneration
Mills E Godwin High School

This experiment was drawn up to find the most effective antibacterial ointment. This was tested by experimenting with planarians. Planarians were chosen because they are models for whole body regeneration. Finding the most effective antibacterial ointment would help close wounds faster and prevent the spread of infections. They do this by stopping the growth of the bacteria within a wound. Neosporin, Polysporin, and Bacitracin are the most common ointments used worldwide to treat wounds and infections. It was hypothesized that the Polysporin would help the planarians regenerate the fastest. The control for this experiment was water so there was a way to see if the results had any effect on planarian growth. 100 planarians were used for this experiment. 25 planarians were used for each independent variable level. The ointments would be applied to the planarians each day using a milligram measuring spoon. The planarians were observed over a two-week testing period to see when they would fully regenerate. After experimenting, results were drawn which concluded that planarians were able to regenerate the fastest when they were applied with Polysporin. After conducting a descriptive stats test, a low standard deviation and variance was drawn. This means that the data was more centered around the average meaning the data wasn't very spread out. The inferential stats test showed that the calculated value was greater than the table value, meaning that the data was significant. The research hypothesis was supported because Polysporin uses substances from both Bacitracin and Neosporin to create an all-round better substance.

James Lee -The Effect of Over-the-counter Drugs on Earthworm Locomotion
Mills E Godwin High School

Throughout the world, earthworms serve a major role in agriculture and the soil. The behavior of earthworms can show the state of the soil that it's burrowed in. When drugs and medications are dumped into the soil, certain negative effects can occur. Agriculturally, when medications are dumped onto fields, the crops that are consumed by humans can be affected by growing in contaminated soil. In order to determine the true effects of drugs that spill onto soil, earthworms were exposed to the most common over-the-counter drugs taken by America. Tylenol and Advil solutions were exposed to the earthworms, and earthworm locomotion was quantitatively measured with a ranking system of one to five following 48 hours. The different solutions tested were the distilled water or the control group, the Advil group, the Tylenol group, and the group combining Tylenol and Advil into one solution. It was hypothesized that the combination group would experience the lowest earthworm locomotion. Following data collection, a chi-square test was performed on the data observed. The frequency distribution was also calculated, and the group with the highest locomotion was the Tylenol group while Advil contained the lowest. The Tylenol group contained data that was significantly different while the other three groups of Advil, distilled water, and combination group demonstrated data that was not significant. The insignificant data can be due to chance or human error. For future research, more efficient measurement techniques should be used such as using more than one observer in data collection.

Nicholas Thompson -Rationality of Ants
Southwest Virginia Governor's School

Understanding the world in which humans live is very important. Ants are very efficient workers, and humans need to understand them for both understanding the world they live in, as well as trying to understand the ant brain and how it relates to the human brain, so that ant teamwork strategies can be applied to people. There have been multiple studies on whether ants were rational or not. The results varied, because some studies claimed that the choice by the ants in the experiment was because they were rational, and others said it was the natural instinct of ants. Studies have been done with food and different options for a new home. There have been multiple done with both of those options, but the researchers of those experiments interpreted the results in different ways. This study was to see if ants were rational enough to understand the size of a piece of food, compared to the size of what they had to move the food through. *Pogonomyrmex barbatus* (Red Harvester ants) were used, and they were offered two different sized pieces of apple. This was offered in a box that was connected by a tube to where the ants

were supposed to make their nest. Everything was kept the same every day, with only their choice changing. There were three different options that could have been chosen for the apple: none, small, or large. None was chosen a significant amount compared to the other two with it being 76.67% of their choices. Small was 13.33% of their choices, and large was the least chosen with 10%. The conclusion was that ants are rational, because they understood that there was no point in moving the food, since they established their home where the food was. Instead of moving the food, they just re-established their home to make it easy, which supports that they were rational, and used critical thinking.

Dhruv Vijay -The Effect of Different Temperatures with Vitamin A on Planaria Regeneration
Mills E Godwin High School

This study aimed to elucidate the effect of temperature and Vitamin A on the regenerative abilities of planaria, emphasizing their resemblance to human stem cells. The hypothesis proposed that planaria subjected to 23°C and supplemented with Vitamin A would exhibit the most regeneration. The experiment involved three temperature conditions, 3°C, 23°C (control), and 37°C, with a constant Vitamin A concentration of 4%. Planarian regeneration was measured by the length of the planaria in millimeters after 14 days. Safety protocols for handling planaria and Vitamin A were adhered to in the experiment. Groups of 25 planaria were bisected through the middle, and regeneration of the anterior part of each planaria was measured. Each group was placed in the specified temperature conditions for 14 days, with regeneration length measured in millimeters, using a digital caliper. Statistical analysis included t-tests and calculation of variance and standard deviation. Findings revealed the most substantial regeneration at the control temperature of 23°C, showcasing an average regrowth of 3.3 millimeters, as opposed to 1.0 millimeters at 3°C and a notably lower mean of 0.4 millimeters at 37°C, confirming the research hypothesis. The statistical significance was supported by all t-values exceeding the critical t-value, rejecting the null hypothesis across all temperature comparisons. Consequently, the study concludes that temperature, with Vitamin A supplementation, significantly impacts planarian regeneration, with room temperature proving most conducive for regenerative processes for planaria. These observations suggest that environmental and nutritional factors intertwine to significantly influence regenerative outcomes in planaria using neoblasts and humans using stem cells.

Awards

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First Place Category Section Awards

Ann M. Hancock Microbiology and Cellular Biology

Samvrit Rao - In-vitro aided computational approach to identify preclinical drug targets to treat Glioblastoma Multiforme (GBM). *Individual*

VAS Botany Award

Leslie Yang & Thomas Bill - Urine as a Nitrogen Source for *Lepidium sativum*: Creation of a Novel Synthetic Solid Urine Testing Model and Product.

Harrisonburg High School

Rodney C Berry Chemistry Award

Neha Pilliai - The Effect of Road Salt on the Corrosion of Automobile Parts.

Mills Godwin High School

Mathematics

Angelina Guo - A Highly Accurate Detection of Glaucoma with Neural Networks - A Case Study for Early Detection.

Central Virginia Governor's School for Science & Technology

Statistics

Sriyutha Morishetty - An Empirical Analysis of the Existence of Greenwashing in the Wider US Market: A Test on the Efficacy of ESG Scores.

Individual

Physics Award

Minghui Zhang, Maxim Lupariello & Louis Lac To - Electro-Stopping Power.

Governor's School @ Innovation Park

Psychology Award

Kabilan Prasanna - MasterMind: A Novel Multi-Output Model Approach for Detecting Mental Illnesses through Natural Language Processing.

Lightridge High School

VA Peninsula Engineering Award

Aashritha Penumudi - SpecuSafe: A Non-invasive and Intelligent Approach to Cervical Examinations.

Individual

VABE Zoology Award

Rania Lateef - Rhythms and Blues: Examining Potential Health Hazards of Blue Light-induced Circadian Disruption in *Drosophila melanogaster*.

Governor's School @ Innovation Park

Special Interest Awards

Cancer Research Awards

Bhoomika Kaur - Investigating the Therapeutic Potential of Natural Products on Advanced Glycation End Product (AGE) Formation and Function in MyC-CaP Prostate Cancer Cells.

Mills Godwin High School

Yashvir Sabharwal - NephroNet: A Novel Program for Identifying Renal Cell Carcinoma and Generating Synthetic Training Images with Convolutional Neural Networks and Diffusion Models.

Individual

Dr. & Mrs. Preston H. Leake Award in Applied Chemistry

Madeline Levorson - Discovery of Medically Important Lytic Bacteriophage in the Environment.

Thomas Jefferson High School for Science and Technology

Roscoe Hughes Genetics Award

Alice Zhang - The Deficiency of Acid Ceramidase Promotes Intracellular Nanovesicle Biogenesis Contributing to Aortic Stiffness.

Mills Godwin High School

Dr. Smith Shadomy Infectious Diseases Award

Helen Hanke - The Effect of Different Types of Oral Care Rinses on the Growth of
Staphylococcus epidermidis.
Individual

Gamma Sigma Delta Award

Lucien Pozzi - The Effect of Black-strap Molasses as a Foliar Fertilizer on the
Propagation and Leaf Growth of the Critically Endangered Species *Stachys*
matthewsii.
Sabot at Stony Point

Virginia Museum of Natural History Award

Christopher Bevin Ransone - Prevalence of Macroparasites *Polydora websteri* and
Zaops ostreus Within *Crassostrea virginica* in Varying Environmental Conditions.
Chesapeake Bay Governor's School

Virginia Sea Grant

Khadeejah Alsheikh, Kayla Jacqueline Minter & Willow Jean'ne Weeks - Putative
Toxins and their Effect on Copepods in the Chesapeake Bay.
Governor's School @ Innovation Park

Scholarships

Bethel High School Scholarship

Rania Lateef - Rhythms and Blues: Examining Potential Health Hazards of Blue
Light-induced Circadian Disruption in *Drosophila melanogaster*.
Governor's School @ Innovation Park

Henry W. MacKenzie Environmental Scholarship (VEE)

Layla Leo - The Impact of Livestock Antibiotics on Marsh Microbes
Chesapeake Bay Governor's School

Frances & Sydney Lewis Environmental Scholarship (VEE)

Libbie Hospodar - Examining Autochthonous Alternatives to Tropical Coconut Coir
for Shoreline Engineering.
Chesapeake Bay Governor's School

VJAS Honor Awards Middle School

**Dorothy Knowlton Award and Outstanding Research Project
Award, Grade 7**

Dean Lateef - The Perils of Plastic Can Phytochemicals Overcome the Effect of
Microplastics on the Health of *Daphnia magna* (Water Fleas)?
Benton Middle School

**Joyce K Peterson Award Award and Outstanding Research Project,
Grade 8**

Ainsley Davis & Eva Dodd - The Effect of Different Activators on the Stretch of
Slime.
Sabot at Stony Point

VJAS Honor Awards High School

Jones/Ellett (Grade 12)

Caitlin Murphy - Exploring the Use of Reclaimed Eutrophic Water for Growing
Butterhead Lettuce (*Lactuca sativa* var. *capitata*) in a Hydroponic System
Chesapeake Bay Governor's School

VJAS Grand High School Award Grades 9-12

Rania Lateef - Rhythms and Blues: Examining Potential Health Hazards of Blue
Light-induced Circadian Disruption in *Drosophila melanogaster*.
Governor's School @ Innovation Park

**VJAS Delegates to AJAS Grades 9-11
Boston February 12-15, 2025**

Rania Lateef - Rhythms and Blues: Examining Potential Health Hazards of Blue Light-induced Circadian Disruption in *Drosophila melanogaster*.
Governor's School @ Innovation Park

Rhythms and Blues:

Examining Potential Health Hazards of Blue Light-induced Circadian Disruption in *Drosophila melanogaster*

ABSTRACT

Background: Environmental disruption of circadian rhythms can have deleterious consequences for human health. The extent to which artificial blue light from LED lighting, smartphones and tablets affects circadian biology and mental and physical health outcomes is not well known. The main goals of this project were to study the effects of varying blue light exposure on *Drosophila melanogaster*'s (1) lifespan, (2) memory (3) propensity to consume caffeine containing media and (4) gut permeability. **Methods:** Four experimental groups were used: controls, flies with the *tim*⁰¹ mutation, which eliminates circadian behavioral rhythms, flies exposed to 8 hours (BL8) and 12 hours (BL12) of blue (460 nm) light. To assess the effect on lifespan, the percentage of flies surviving over time, within each group, was calculated. Preference for caffeine containing food was evaluated using a constructed choice chamber where caffeine-enriched and regular media were presented to flies. Loss of intestinal barrier function was detected by the presence of a non-absorbable blue food dye outside of the digestive tract after feeding. The aversive phototaxis suppression assay was used to assess learning/memory; flies learned to avoid light that is paired with an aversive stimulus. Group differences were analyzed with survival curves, t-tests, and Chi-square tests as needed. **Results:** Control flies lived significantly longer than the circadian mutants and flies exposed to blue light for 12 hours ($p < 0.001$). Circadian mutant flies demonstrated significant impairment in short-term memory and learning compared to the

control flies ($P = 0.029$) as did the BL12 ($P = 0.009$) and BL8 ($P = 0.008$) groups. A preference for caffeine containing food, after 72 hours of exposure to it, was demonstrated by the circadian mutants (OR 10.52, $p < 0.0001$) as well as the BL12 (OR 6.07, $P < 0.0007$) and BL8 (OR 6.48, $P = 0.0003$) groups. More flies with *tim⁰¹* mutation and 12-hour exposure to blue light demonstrated impaired gut permeability compared to the controls. **Conclusions:** This study show that prolonged exposure to blue light can cause increased mortality, impaired memory, propensity to substance use and accelerated gut aging similar to known circadian mutants; the degree and spectrum of effects may depend on duration of exposure. The health implications of a digital world require closer biologic scrutiny.

INTRODUCTION

Many environmental factors, including light, can disrupt sleep and circadian rhythms. Phase 1 of this project, now published, studied the effects of disrupted circadian rhythms and sleep deprivation on *Drosophila melanogaster*'s lifespan, depression like behaviors, and propensity to consume caffeine containing media (Lateef et al., 2023). The use of LED lighting, smartphones and tablets and the potential hazards of extensive and/or long-term exposure to artificial blue light on our health are not well understood.

Circadian Rhythms and the Circadian Photoreceptor

Circadian rhythms are daily rhythms in behavior or physiology that reoccur approximately every 24 hours in animals, plants, and many microbes. Biologic clocks produce circadian rhythms and regulate their timing but external environmental cues (*Zeitgebers*) especially light, can also affect circadian rhythms (Tahkamo et al., 2019). Humans and other mammals have a master clock in the brain called the suprachiasmatic nucleus, or SCN, which is located in the hypothalamus and receives direct input from the retina in our eyes. The SCN then coordinates all the other biologic clocks located in various tissues and organs keeping them in sync. The SCN also regulates our sleep-wake

cycle by receiving light input via the optic nerve and controlling the production of the hormone melatonin, which is released by the pineal gland (See Figure 1) (Walh et al., 2019). While the sleep-wake cycle is one of the most common and obvious circadian cycles many others exist such as body temperature, hormone release, eating habits and digestion. When circadian rhythms are disrupted, it can affect everything from learning and memory to metabolic and cardiovascular disease (Videnovic and Zee 2015).

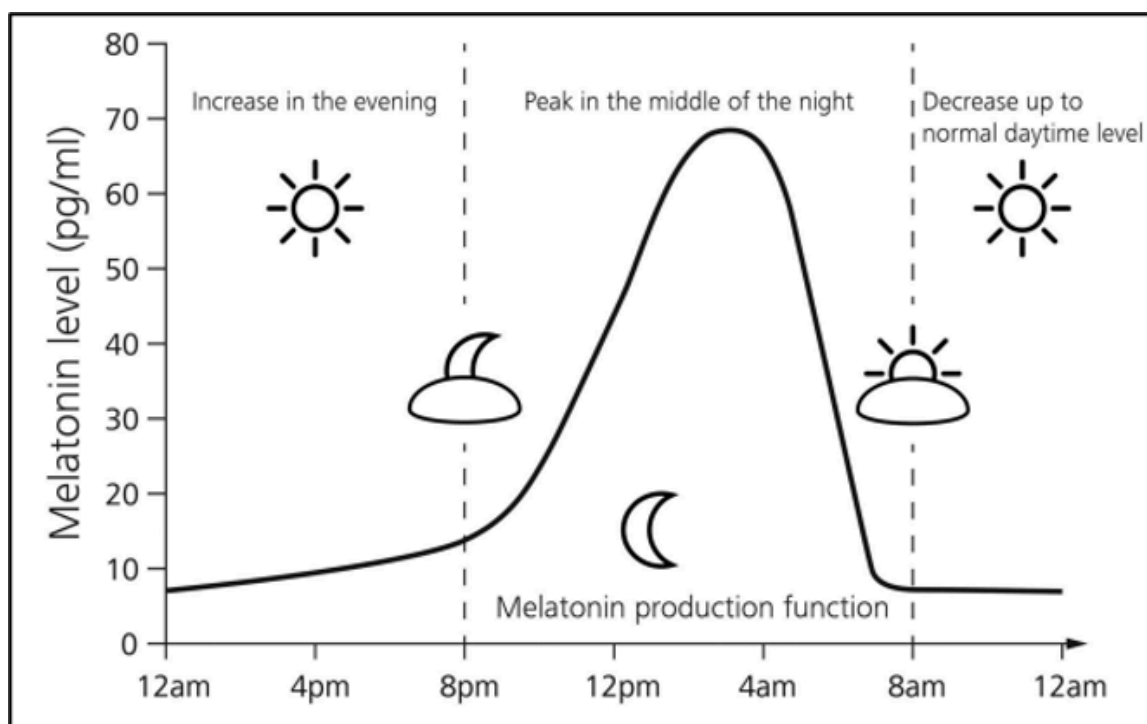


Figure 1: Physiological melatonin profile across a day. Declining light exposure in the evening results in increased melatonin secretion with peak levels in the middle of the night. (Walh et al 2019).

Within the human eye, a specific photoreceptor, especially sensitive to blue light, was discovered in 1998. These photoreceptors, containing the pigment melanopsin, are a subset of the human retinal ganglion cells (RGCs) and are called intrinsic photosensitive retinal ganglion cells (ipRGCs) (Provencio et al., 1998). Although they represent only 1% of the RGCs found in the retina, IPRGCs ensure non-image forming functions like the

pupillary response and circadian entrainment even among blind animals. The absorption spectra of the ipRGCs and of melanopsin peaks around 480 nm in the blue section of the visible light spectrum and this photic information is conveyed to the SCN thus aligning internal biological processes with external environmental time (Hattar et al., 2003).

Blue Light Impact on Circadian Rhythms and Human Health

While circadian synchronization by blue light is beneficial, it is modulated by light spectral composition, the timing of exposure and its intensity. Blue light exposure during the day suppresses melatonin secretion, allowing organisms to stay alert and active during the day but chronic exposure to blue light directly before bedtime, could negatively impact sleep quality, circadian phase, and cycle durations in all organ systems (Wahl et al, 2019). While the blue component of daylight peaks at midday, the extensive use of Light Emitting Devices (LEDs) exposes us to higher amounts of blue light throughout the day and

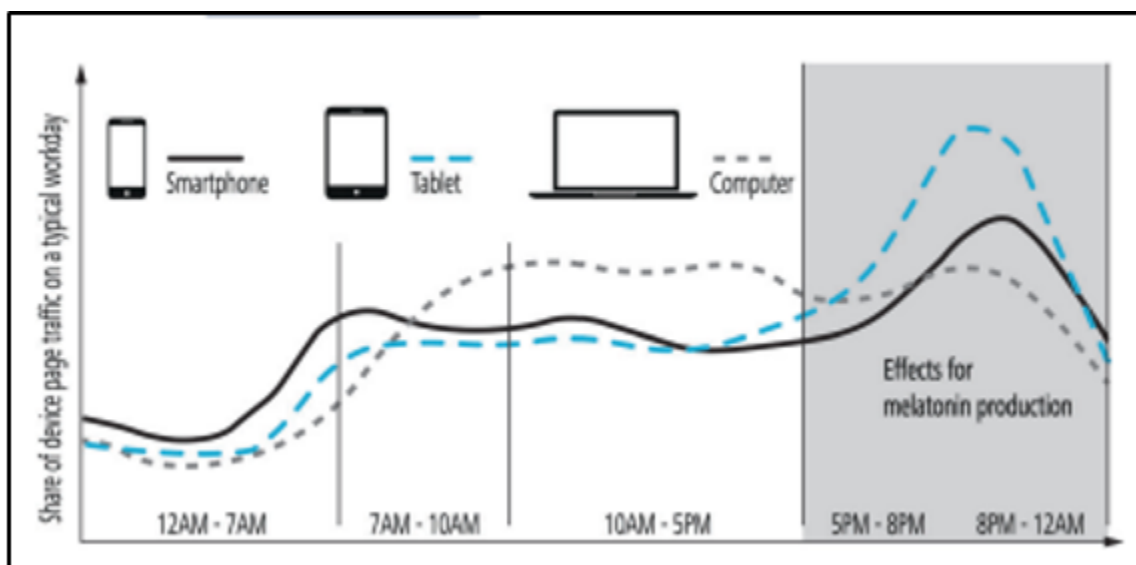


Figure 2: LED Usage modelled during the day (Wahl et. al., 2019) continues in the evening and at night (See Figure 2). The substantial and increasing use of LED lighting, smartphones and tablets is undeniable. Yet the potential hazards of extensive and/or long-term exposure to artificial blue light on our health, cognition, and aging are not well understood.

Prolonged blue light exposure has been studied in fruit flies to some degree and showed that constant or prolonged exposure to blue light can shorten the fly lifespan and cause retinal damage and neurodegeneration (Nash et al., 2019; Yang et al, 2022). However, the effect of varying blue light duration is on varied mental and physical health outcomes unknown.

In this study wild type flies were exposed to blue wavelength enriched light for varying periods of time and the impact on lifespan, memory, addiction, and gut permeability will be compared with flies who harbor a clock mutation, *timeless* (*tim*⁰¹), that produces severely disrupted circadian rhythms (Sehgal et al, 1994)

Hypotheses:

It was hypothesized that flies exposed to 8 and 12 hours of blue light will demonstrate negative impacts on lifespan, memory, increased caffeine seeking behaviors, and accelerated aging as demonstrated by increased gut permeability.

METHODS AND MATERIALS

Fly Stocks (wild-type (Samarkand strain) and Timeless y[1] w[*]; tim[01] *Drosophila*) were obtained from Bloomington Stock Center (Bloomington, Indiana) and raised at 23 degrees C on standard cornmeal-molasses medium.

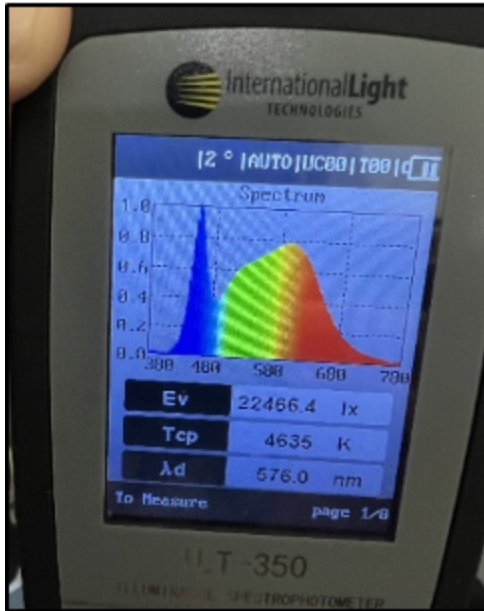


Figure 3: Wavelength measurement using Spectrophotometer

Blue Light exposure: a light bulb with blue enriched spectra of light was used and exposure periods were 8 hours (7 am – 3 pm) or 12 hours (7 am to 7 pm) during the day (Figure 3).

Outcomes

Longevity: 20 to 30 adult flies (10 days post eclosion) were placed in each of three vials, per condition (control, Tim, Blue light 8 hours, Blue Light 12 hours). Flies were transferred to new vials every 3 days to avoid including their offspring in the longevity count. Flies were counted daily, and the number of dead flies, number of living flies, and the percentage of surviving flies were recorded.

Caffeine Addiction: Caffeine tablets were be crushed and boiled with water at a concentration of 0.5 mg/ml When individual caffeine particles have limited visibility, the solution will then be cooled while the standard medium (as aforementioned) was

prepared for the three experimental groups. For each condition, a choice chamber was constructed as shown in figure 4.

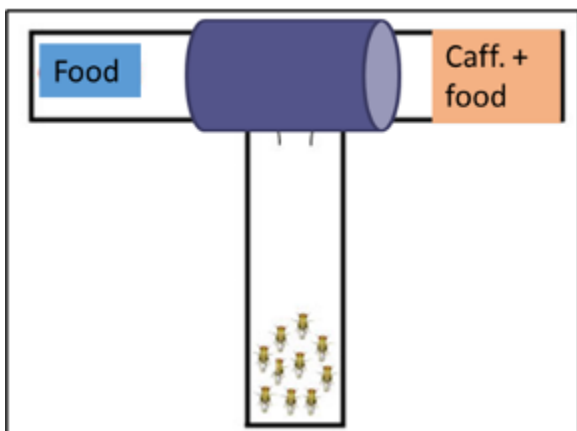


Figure 4: Choice Chamber where flies can show preference for regular vs. caffeine containing media.

Each choice chamber had two options for the cohort of flies: caffeinated medium or un-caffeinated medium. The caffeinated vial combined the standard *Drosophila* medium with the prepared caffeine solution (ratio 1:1); the un-caffeinated vial combined the standard medium with distilled water (ratio 1:1). After vials are prepared and inserted into the PVC pipe, the appropriate cohort of flies were introduced via the remaining opening.

Flies were given a 20-minute acclimation period before recording the first observation. Each observation noted the number of flies in each section of the chamber (including the middle). In a study researching preferential ethanol consumption in *Drosophila*, the relative preference for ethanol increased over the course of 3-5 days (Kaun et al., 2012). Therefore, the final observation was taken after 3 successive days.

Learning and Memory: Associative learning and intact memory help organisms, including insects, adapt to their environment which is essential for survival. Fly

behavioral assays, involving Pavlovian conditioning tests of memory and learning, are well established (Le Bourg & Buecher (2002). In this study, suppression of photopositive tendencies was evaluated in all experimental groups. Phototaxis represents the fly's

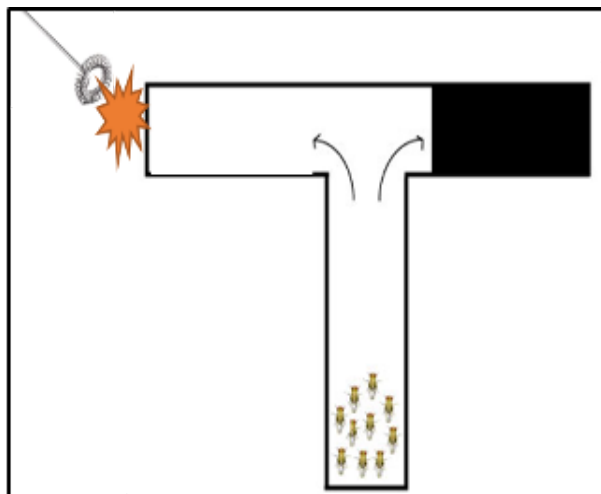


Figure 5: Light-Dark Choice Chamber, where light is coupled with an aversive stimuli.

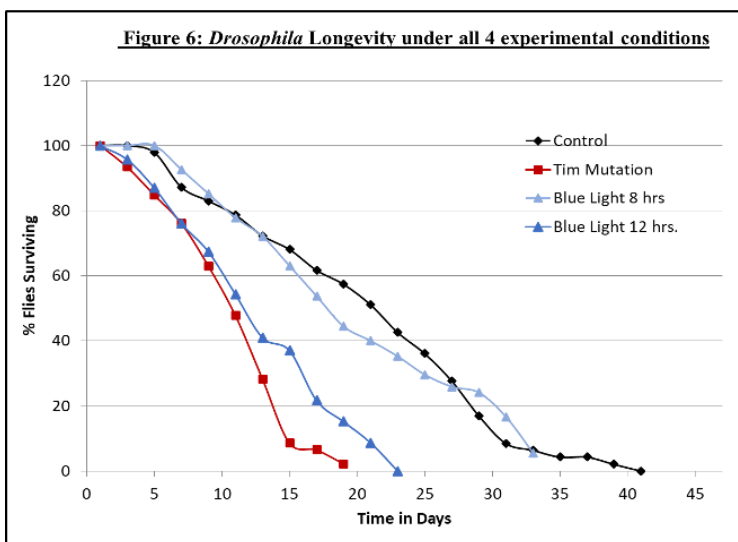
natural affinity to migrate towards light, but this innate tendency can be suppressed when flies are subjected to an aversive stimulus coupled with light exposure (Le Bourg and Buecher, 2002). A choice chamber was created with one end of the chamber covered with opaque black material and the other end open to ambient light (figure 5). When flies migrated to the lit chamber, they received a noxious stimulus delivered via a buzzing device causing them to leave the lit side. The process was repeated during a 1-minute interval for a total of 5 times and after that the number of flies in the darkened versus light chambers was documented. The proportion of flies found in the dark chamber (i.e. the ones who “learned” to avoid potential danger) was defined as the learning index.

Gut Permeability as an Index of Aging: Aging flies have increased intestinal barrier dysfunction (Salazar et al., 2023) The methods for this assay involve feeding the flies on a normal media with the addition of Blue dye No. 1 (2.5% wt./vol, ThermoFisher Scientific). After 72 hours had passed, the flies were observed using a basic microscope

and the percentage of flies that have blue dye dispersed throughout their body (*Smurfs*) will be recorded.

Data Analysis: Mortality curves were statistically analyzed by using the Log-rank test in GraphPad Prism 6. For the memory and addiction assays, raw data will be taken, and unpaired t-tests and chi-square analysis were conducted for each experimental group. and odds ratios were also calculated. **RESULTS**

Longevity: survival curves were plotted using a Kaplan Meir model (figure 6) and showed that wild type flies who were not exposed to anything other than natural light dark cycles lived much longer than flies the Tim^{01} mutation and the flies exposed to 12 hours of blue light. The flies exposed to blue light for 8 hours did not have any impact on their lifespan when compared to the control flies.



Median survival for each group as well as hazard ratios relative to the control flies are shown in Table 1. There was also a significant difference between the flies exposed to 12 hours versus 8 hours of blue light ($p < 0.0001$, hazard ratio of 1.5, 1.01-2.2).

Propensity to Caffeine: as shown in Table 2 and Figure 7, significantly more flies were observed in the vial

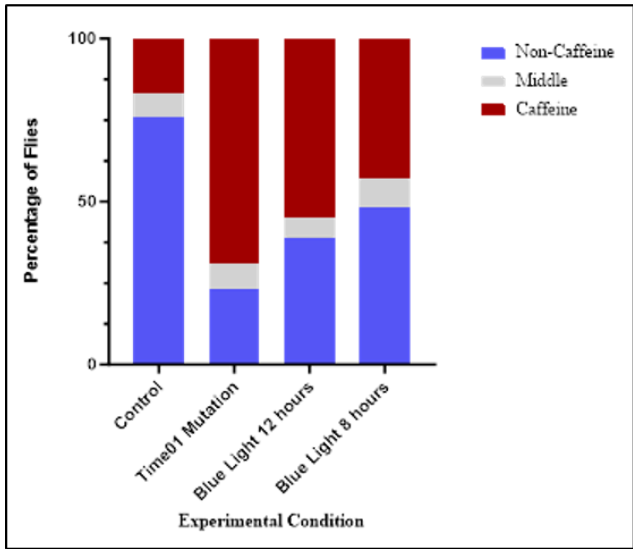


Figure 7: Proportions of observed flies in regions of the choice chamber are shown.

Fly Cohort	Median Survival (days)	Hazard Ratio Relative to Control (95% CI)	P Value
Controls	22.5	n/a	n/a
Circadian Mutants	11.0	6.77 (3.91 to 11.71)	<0.0001

Blue Light 12 hours	12.0	2.752 (1.73 to 4.37)	<0.0001
Blue Light 8 hours	18.0	1.26 (0.85 to 1.86)	0.2261

Table 2: Proportion of flies in the caffeinated chamber (after 72 hours), by group

Fly Cohort	Median Survival (days)	Hazard Ratio Relative to Control (95% CI)	P Value
Controls	22.5	n/a	n/a
Circadian Mutants	11.0	6.77 (3.91 to 11.71)	<0.0001

Fly Cohort	Flies in Caff. Chamber n/Total (%)	Ratio of Relat to Control (95% CI)	P Value
Controls	7/41 (17.07%)	1.00	N/A
Circadian Mutants	26/38 (75.0%)	10.52 (3.70-28.52)	<0.0001
Blue Light	20/36	6.07	0.0007

12 hours	(58.82%)	(2.17-15.83)	
Blue Light	15/35	6.48	0.0003
8 hours	(46.88)	(2.28-17.13)	

Table 1: Survival Code Analysis

containing caffeinated medium, for the circadian mutants as well as the groups exposed to blue light for 12 and 8 hours. More specifically, compared to the control where about 17% of flies were on the caffeinated side, the circadian mutant group had 75% of flies in the caffeinated medium and they almost 11 times as likely to prefer caffeinated media compared to the controls ($P < .0001$). The BL12 group was also more likely to prefer caffeine containing media compared with the controls (Odds Ratio 6.07, $P = 0.0007$), as were the BL8 group (Odds Ratio 6.48, $P = 0.0003$).

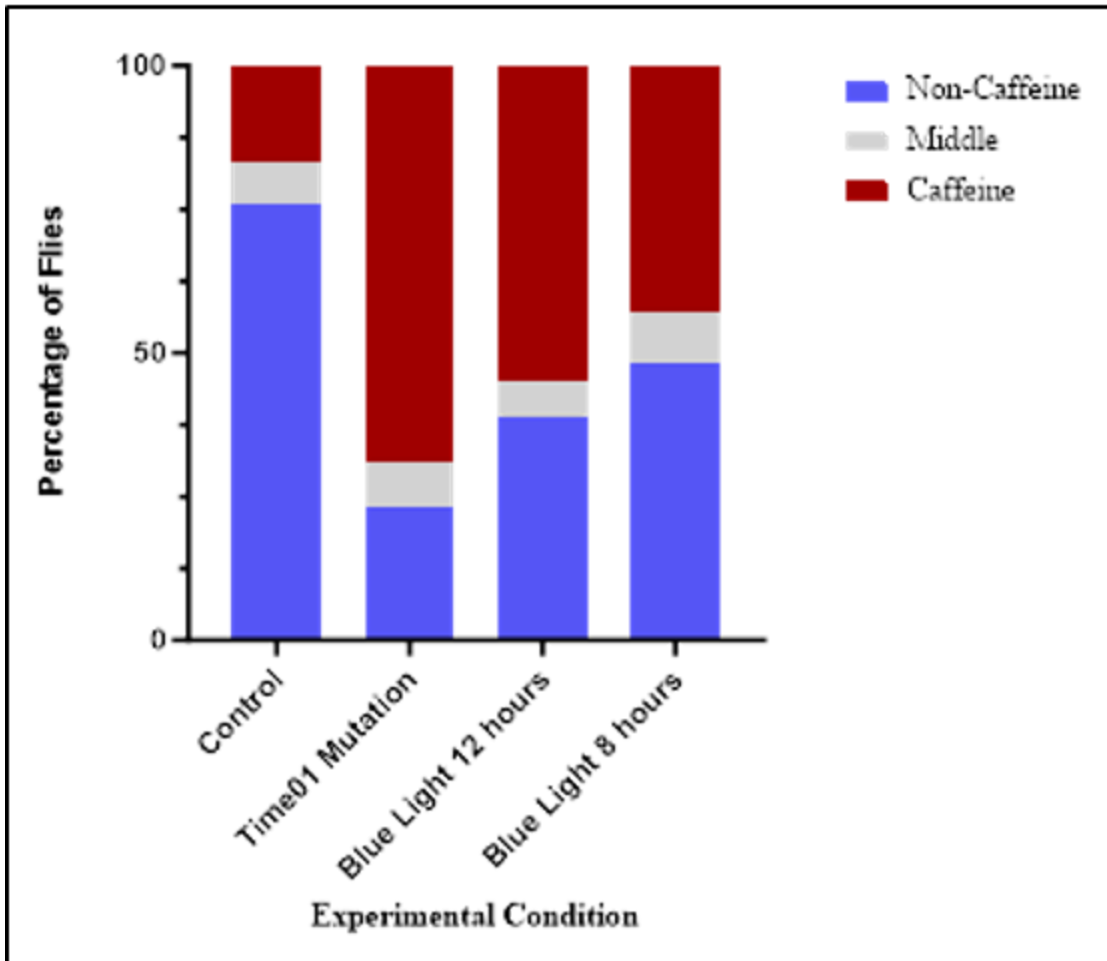


Figure 7: Proportions of observed flies in regions of the choice chamber are shown.

Learning and Memory: After receiving an aversive stimulus, the number of flies who “learned” to avoid light were recorded over 3 trials. The Learning index was defined as the percentage of flies that successfully suppressed phototaxis (or the innate desire to migrate towards light) and migrated to the unlit side of the chamber. As shown in figure 8, flies with the Tim^{01} mutation demonstrated significant impairment in short-term memory and learning compared to the control flies (p-value = 0.0288). Flies exposed to

blue light for 12 hours also had impaired memory and learning (p-value 0.0089) as did the flies exposed to blue light for 8 hours (0.0083).

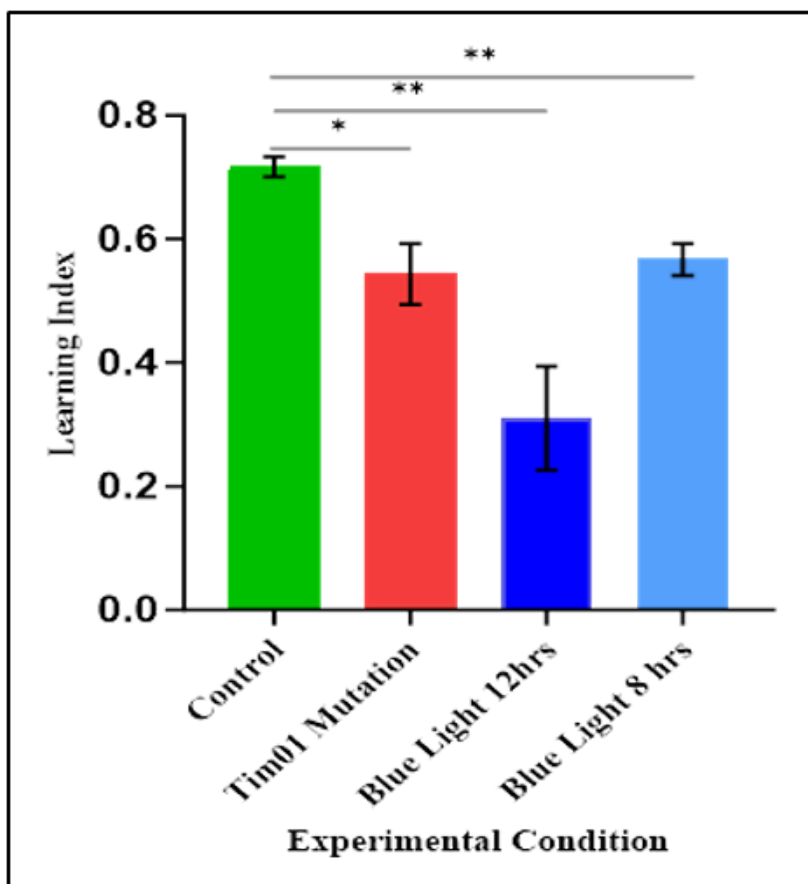


Figure 8: Short-term Memory Evaluation by Aversive Phototaxis Suppression Assay. Learning Index calculated based on percentage of flies who “learned” to avoid light

Disruption of Gut Permeability as a Function of Aging

In the group of flies with circadian mutation, 23.1% of flies exhibited the *Smurf* phenotype compared to controls at 0% (p-value 0.0248). Exposure to blue light for 12 hours, caused 13.6% of flies to exhibit the *Smurf* phenotype, but did not reach statistical significance (p-value 0.2326).

DISCUSSION and CONCLUSIONS

The purpose of this study was to utilize *Drosophila melanogaster* as a model organism and evaluate the extent to which blue light induced circadian disruption can impact physical and mental health outcomes. Compared with controls, flies with the *timeless* gene mutation (*tim⁰¹*) have a significantly shorter lifespan as do flies exposed to 12 hours of blue enriched light. Circadian mutant flies, as well as those exposed to blue light for 12 hours or 8 hours, preferred the caffeinated medium, indicating increased risk for substance use among all these groups. Memory and learning were most affected for the flies exposed to blue light for 12 hours but learning impairment was also significant among the flies with the *timeless* gene mutation and the flies exposed to blue light for only 8 hours. Intestinal barrier dysfunction, which can be a sign of aging in flies, was seen in the circadian mutants as well as flies with 12 hours of blue light exposure.

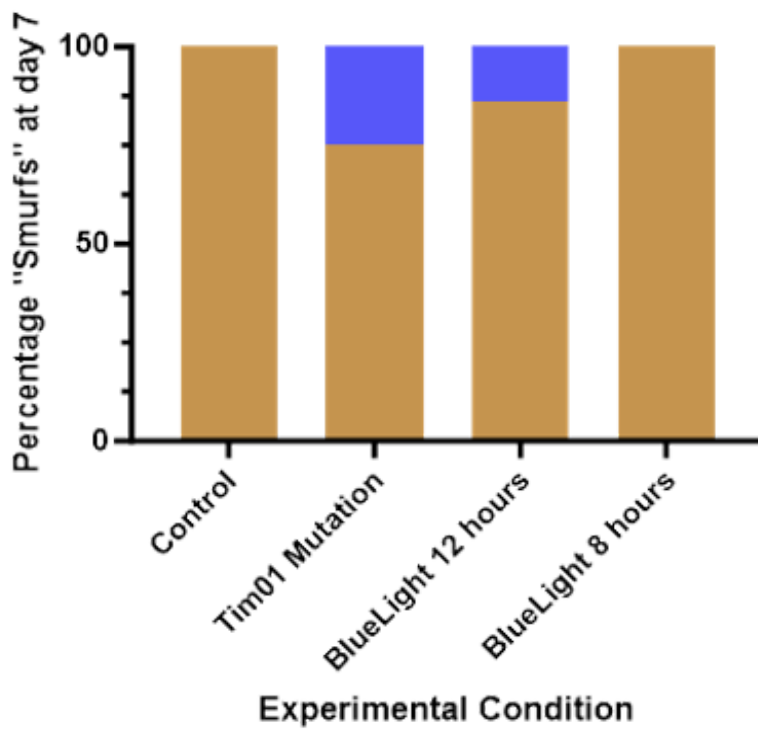


Figure 9. Intestinal Integrity at 72 hours post dye ingestion



Figure 10 a. Control and Smurf fly Katzenberger, 2013



Figure 10 b. Smurf fly with Tim⁰¹ Mutation

Circadian Dysfunction and Mortality

Results from this study provide robust support and replicate prior work that shows increased mortality among flies with *tim*⁰¹ mutation (Lateef et al, 2023). The association is likely explained by the desynchronization of various internal clocks in the body (Golambek et al., 2013), causing many physiologic alterations and inducing pathology. Flies exposed to prolonged 12 hours of blue light showed similar reductions in lifespan. This is consistent with prior work by research which showed that blue light exposure decreased fly longevity, while causing retinal photoreceptor damage and brain neurodegeneration with increased vacuoles (Nash et al., 2019).

The long-term consequences of increased daily blue light exposure across the human lifespan are not known but studies indicate that altered circadian rhythms such as seen in night shift workers have been associated with a higher risk of breast cancer, cardiovascular disease, and metabolic derangements (Knutsson, 2003). Our data, along with prior literature, suggests that the circadian derangements brought on by prolonged and consistent blue light exposure can be significant enough to induce disease states and diminish longevity.

Circadian Dysfunction and Addiction

Like mood disorders, substance use has been linked to disordered sleep (Gromov et al., 2009). In this experiment, flies with both circadian dysfunction and blue light exposure for 8 or 12 hours showed increased propensity towards caffeine containing food. This suggests that even limited blue light exposure can disrupt circadian biology and sleep enough to cause alterations in brain reward/addiction mechanisms. This correlates with longitudinal studies that show youth who sleep less go on to consume more cigarettes and alcohol in later years (Warren et al, 2017).

The dopamine neurotransmitter system in the brain is responsible for motivation and drug intake. All dopamine related behaviors linked to the motivational and arousal states, show

daily rhythms that are regulated by the SCN. Thus impaired circadian rhythms can disrupt normal motivation and reward pathways leading to pathology such as substance addiction (Mendoza and Challet, 2014). Research also suggests that sleep deprivation can downregulate dopamine D2 receptors that are involved in wakefulness (Volkow et al., 2012). This in turn could cause behaviors leading to drug use, which produces huge amounts of dopamine, to compensate for this deficit. Caffeine in particular increases the dopamine D2/D3 receptor availability in the brain (Volkow et al., 2015), which could explain this study's findings.

Circadian Dysfunction and Learning/Memory

Compared to the controls, all three experimental groups showed significantly impaired learning and memory. Interestingly the group exposed to blue light for 12 hours had the worst cognitive performance suggesting that blue light may impact neurons directly, in addition to disrupting circadian pathways through the SCN. It is well established that circadian rhythms affect cognition and memory formation in rats (Valentinuzzi VS et al., 2004, Moura PJ et al, 2009) and fruit flies (Lyons and Roman, 2008) and peak cognitive performance occurs at times of the day when melatonin levels are low (Gerstner and Yin 2010). On a molecular level, the brain structure responsible for memory formation, the hippocampus, has circadian cycling of secondary messengers which parallel time of the day. Disruption of the circadian rhythm of such messenger systems like the cAMP-MAPK-CREB cascade in the hippocampus, by pharmacological agents or by light exposure of animals, impaired memory formation (Eckel-Mahan et al., 2008). From our study it is apparent that even less than constant light exposure, especially with blue enriched light, can cause a measurable decline in the cognitive performance of *Drosophila melanogaster*.

Circadian Dysfunction and Intestinal Integrity/Aging

Intestinal integrity, in all organisms, creates a selectively permeable barrier allowing essential nutrients to be absorbed while keeping harmful agents like microbes and environmental toxins out. Previous literature shows that structural and functional impairments in the intestinal lining occur with aging flies and mammals (Kirkwood et al, 2004; Biteau et al, 2008). In fact, increased intestinal permeability in flies, assessed using the same blue dye used in this experiment, is linked to multiple physiologic markers of aging, including the expression of specific metabolic and inflammatory markers, and reduced spontaneous physical activity (Rera et al, 2012). It is known that disrupted circadian rhythms impair gut physiology and motility (Duboc et al, 2020). Remarkably, far more melatonin is produced in the gut than by the pineal gland and it is also under the control of the SCN or central pacemaker (Hooherwerf 2006). Utilizing the same Smurf assay as Rera's experiment, this study showed increased intestinal permeability among the circadian mutant flies and those with blue light exposure for 12 hours; this highlights, for the first time, that blue light induced circadian desynchronization can cause intestinal barrier dysfunction which is a reliable marker of aging in flies.

Strengths and Limitations

This work represents a comprehensive and systematic first look at the implications of disrupted circadian rhythms, and how blue light can play a role in this disruption, across multiple biologic systems. The findings, with regards to both physical and mental health, are compelling and require more nuanced and in-depth studies that should also be replicated in mammalian models. Experiments varying exposure times and at different parts of the day-night cycle are also warranted. For example, this study did not address whether 8 hours of exposure during daylight hours is better than the same duration of exposure in evening/nighttime hours.

Implications for a digital world

While the blue spectral component of daylight enhances our learning during the day by promoting alert wakefulness, exposure to blue light at night can suppress melatonin causing impaired sleep wake cycles as well as desynchronization of the central pacemaker (SCN) and multiple peripheral pacemakers in various organ systems and tissues. The specific impacts on human health are complex (Tähkämö et al., 2019), but there are definite indications of an association between deleterious health outcomes and the light pollution, from the current study and others (Bedrosian and Nelson 2013; Cho et al. 2015; Reiter et al. 2007), especially via circadian rhythm disruption and compromised melatonin production. A study comparing reading a printed book in reflected light versus reading a light-emitting eReader (LE-eBook) in the hours before bedtime found that the LE-eBook decreased subjective sleepiness, lengthened sleep latency, delayed the phase of the melatonin circadian rhythm, and impaired alertness the following morning (Chang et al., 2015).

Yet exposure to blue light in human societies and even in the natural environment is rising precipitously. The World Health Organization, in 2020, formally recognized digital addiction as a worldwide problem, which leads to impaired management of time, energy, and attention during the day and disturbed sleep at night (WHO 2020). On average, across the world, individuals aged 16 to 64 spend 6 hours and 37 minutes per day on screens (Independent 2024). According to the CDC, screen time is highest among 11- to -14-year-old children, at around 9 hours per day (CDC) and teens from lower SES backgrounds spend about 2 hours more per day on screens than their wealthier counterparts.

So where do we go from here? Research in both animal and human systems looking at specific amounts, types, and timing of blue light exposure is critical. Based on accumulating evidence, measures to shield and protect humans from over consumption of specific light wavelengths may become the responsibility of electronic device

manufacturers. The health implications of a digital world can no longer be ignored and must be subjected to closer biologic scrutiny and reasonable regulations.

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Alternates to American Junior Academy of Science

American Junior Academy of Science #2

Samvrit Rao – In-vitro aided computational approach to identify preclinical drug targets to treat Glioblastoma Multiforme (GBM)

Individual

Title: In-vitro aided computational approach to identify preclinical drug targets to treat Glioblastoma Multiforme (GBM)

Abstract:

Glioblastoma multiforme (GBM), is a highly malignant and prevalent form of brain cancer that continues to be largely incurable despite advancements in treatment modalities. The 2-year survival rate for individuals afflicted with GBM is approximately 18%. Recent studies have revealed that intercellular communication channels, known as Tunneling Nanotubes (TNTs), play a crucial role in the progression of GBM by facilitating the transfer of tumorigenic materials, thereby rendering the tumor resistant to treatment. The primary goal of my research project was to identify novel molecular drug targets using in-vitro aided computational approaches to prevent transfer of tumorigenic cargo through the TNTs between treatment-resistant and naive-healthy cells, to achieve GBM remission. Glioblastoma stem cells from autopsy tissue were cultured with naive astrocytes, laser micro dissected to analyze TNTs and omics-aided pathway analysis was performed to identify a key molecular drug target, JMJD8 (Jumonji domain containing 8), which was confirmed through Western Blot and Immunohistochemistry. Further, computational analysis using Tumor Cancer Genomic Atlas database revealed that the drug, Paclitaxel, alters expression of JMJD8 through secondary mediators, inferring that it can be repurposed to target TNTs.

Additionally, by computationally reverse engineering the search, having Vinblastine and Cytochalasin as anchors, 5 possible novel modifiable drug targets were identified. In summary, this study identifies a key molecular drug target, JMJD8; showcased that Paclitaxel could be repurposed to achieve GBM tumor remission and brought to attention 5 additional molecular targets. These novel drug targets and repurposed drugs can potentially alter GBM tumor progression and increase survival.

Introduction:

Glioblastoma Multiforme (GBM) is one of the most fatal brain cancers in the world. GBM accounts for over 49.1% of primary malignant brain tumors & has a 5-year survival rate for GBM hovers around 4-7% (Miller et al. 2021). The median survival rate for GBM is just under 15 months (Grech et al. 2020) and only 17% of patients survive 2 years after diagnosis (Hanif et al. 2017). GBM is incredibly hard to target and treat due to the disease's ability to evade standard treatment methods such as chemotherapy, radiation, and surgery.

The most common treatment strategy for the majority of GBM patients is MSR, or Maximum Safe Resection surgery (Fernandes et al. 2017). MSR is the resection of the tumor from the brain is a very invasive and complex procedure that has significant adverse effects. In most patients, based on the location of the tumor in the brain, the entire tumor cannot be removed without impacting brain function. Due to this reason, the recurrence rate of Glioblastoma in situ is almost 90% (Chen et al. 2017) and hard to treat. Another alternative to MSR is the use of Chemotherapy and the drug of choice is Temozolomide, or TMZ. TMZ is frequently utilized to treat Brain cancers such as GBM. However, TMZ is only effective for approximately less than 50% of patients and this selective prognosis has been attributed to genetics, specifically MGMT promoter methylation (Rivera et al. 2010). The third alternative treatment strategy is radiation therapy, but for GBM the effectiveness of radiation therapy is less than optimal and is associated with recurrence of the tumor (Tan et al. 2020)

The goal of my project was to better understand the resistance and susceptibility characteristics of GBM and to utilize this knowledge to identify pre-clinical treatment targets. To better understand how GBM recurrence occurs, it is important to understand the cellular processes involved in tumorigenesis. Glioma Stem Cells, or GSCs, are one of the important cell types responsible for recurrence of GBM (Valdebenito et al. 2021). GSCs are resistant to therapy (Kostopoulou et al. 2017) and can also proliferate very easily due to the unique phenotype characteristics. This observation is colloquially termed as the “Stem cell model” of GBM proliferation (Pinto et al. 2021). This model suggests that only a subset of cancer cells have the potential to indefinitely self-renew, initiate and maintain tumor growth along with facilitating other cells to gain properties such as resistance to chemotherapy and radiation (Valdebenito et al. 2021).

Mitochondria plays a key role in the progression of GBM. The mitochondria serve many pivotal functions such as energy production, providing the precursors for multiple macromolecules such as lipids and nucleotides, and aiding differentiation, apoptosis, and the cell cycle. In normal cells, when the mitochondria are exposed to treatments such as chemotherapy, the many cellular components lyse, causing the cell to die. However, in glioblastoma multiforme (GBM) cells exposed to chemotherapy, the mitochondria expand, causing the endoplasmic reticulum to constrict it, creating two separate mitochondria. Both mitochondria are cancerous, and the secondary mitochondria are transmitted via tunneling nanotubes (TNTs) to non-cancerous cells, which can include both GSCs and Astrocytes. The distributed mitochondria lead to the non-cancerous cells adapting to the new, tumor-induced hypoxic environment (due to the cells being packed together) and gaining resistance to the TMZ drug. One of the key characteristics that enables GSCs and Cancerous Astrocytes to self-renew and maintain tumor growth are the cellular connections that form between cells known as Tunneling Nanotubes, or TNTs. These TNTs are known to facilitate communication between cells in the brain and TNTs are important in the pathogenesis of many diseases (Valdebenito et al. 2021). TNTs play a key role in GBM disease prognosis

through the transfer of O-Methylguanine-DNA methyltransferase (MGMT) between drug resistant and sensitive cells (Valdebenito et al. 2021). TNTs also enable the transmission of organelles between cells, including mitochondria and proteins. The transfer of these organelles leads to the sensitive cell receiving the resistant mitochondria, in turn making the sensitive cell now resistant to treatment, enabling further proliferation of the tumor (Griguer et al. 2011). The rationale for my experiment is to identify preclinical target proteins in the TNTs that enable mitochondrial transfer between resistant and sensitive cells. In addition, the sensitivity of identified targets and associated proteins to existing chemotherapy agents and other approved drug candidates using advanced machine learning based techniques and data from the cancer genome atlas (TCGA) database was also explored. The results of the experiment can potentially lead to significant discoveries in cancer biology along with enabling the identification of new drugs that could potentially improve the treatment outlook for brain cancers such as Glioblastoma Multiforme.

In cancer, a relationship between carcinogenesis and mitochondrial dysfunction has been long established and, in the study, they propose that TNTs contribute to the spread of malignant mitochondria into neighboring cells, leading to the adaptation of tumor-induced hypoxic conditions (Valdebenito et al. 2021). Along with the mitochondria multiplication and transmission between the cells, there are key proteins identified that were determined to be one of the primary methods by which the drug sensitivity was spreading through the TNTs cell to cell communication leading to evasion of treatment. These proteins can be targeted to increase the sensitivity of GSCs and Astrocytes to TMZ (temozolomide), allowing for the chemotherapy to be much more effective. In addition, these proteins can aid the development of new, novel drugs that can eliminate the tumor/cancer entirely by blocking the spread through TNTs.

Materials and Methods:

Cells and Human Tissues: All cell lines in this study were acquired through surgical tumor resection by surgeons at the MD Anderson Cancer center in Houston, Texas. In addition, Human tissues were part of an ongoing research protocol approved by Rutgers University (IRB protocols Pro2012001303 and Pro20140000794). Furthermore, all human tissues, cells, and blood were de-identified (exemption #4). To understand which proteins or possible drug targets are responsible for intracellular transport of cargo between cells, several in-vitro cell-based experiments were performed. The Glioblastoma Stem Cells and Astrocytes obtained from human samples with differential growth characteristics were grown using recommended cell culture media. The cultured cells were incubated 7- 14 days to allow the Tunneling Nanotubes to form between the cells. When growing the cells, Laminin is coated on the culture plates, primarily to make sure that the cells stick to the plate along with making them more easily identifiable/analyzable. After the GSCs/Astrocytes are cultured, the next step was to document the rate of growth of different cell lines and run the western blots to identify key proteins that are differentially expressed in cells with and without TNTs. Western blotting is a laboratory technique used to detect specific proteins in tissue samples. The method involves using gel electrophoresis to separate the sample's proteins and separated proteins are transferred out of the gel to the surface of a membrane and this membrane is exposed to a tagged detectable antibody specific to the certain proteins.

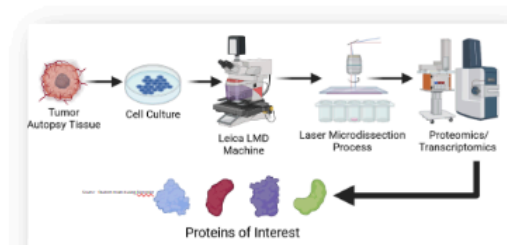
Statistical Analysis: Once the protein targets responsible for transfer of cargo in the TNTs were identified, machine learning models were utilized to explore the sensitivity of these target proteins or associated proteins to common chemotherapy agents and other approved drugs. The model was built utilizing 2 datasets (Drug sensitivity & gene expression) from the TCGA Database utilizing Bayesian Nets. The first step was to import the data from a .csv file and clean it to make sure that the model understands the data that is inputted, and this was done using the Tidyverse & BSDA Libraries. After the data was imported and

formatted, the next step was to begin the structured learning of the Bayesian Nets. To begin, only one dataset (drug sensitivity data) was inputted, and the other dataset (gene expression) was incorporated after. The next step was to begin the creation of a blacklist using the bnlearn library. A blacklist is a technique that can be utilized to get rid of all prior structural knowledge that the model contains to reduce the chance of false positives as well as to ensure that the model is only creating a network based only on the data input. After the blacklist has been created, the next step was to integrate the proteins of interest into the Bayesian Nets and run the visualization. Once this was complete, the bayesian nets were visualized using the bnviewer library. From this model, we then determined which targets are most sensitive to commonly used chemotherapy drugs and can be possibly translated into therapies.

Immunohistochemistry: After analyzing the key target proteins using western blots, the differentially expressed proteins of interest were visualized in the cells using immunohistochemistry. These proteins were stained using specific antibodies tagged with Alexa Fluor 455 Dye that will make the proteins easily identifiable through the microscope. Before visualizing the cells, the slides with the stained cells were attached to glass coverslips using Prolong Gold Antifade reagent with DAPI and incubated at room temperature in the dark overnight. Following incubation, the cells were imaged using Nikon NIS software packages. Upon visualization and image analysis, one can determine the expression patterns of target proteins in higher/lower tumorigenic environments. Similar staining techniques were used on the tunneling nanotubes and one can utilize Leica Laser Technology to micro-dissect the Tunneling Nanotubes to identify target proteins responsible for transport of cargo between cells.

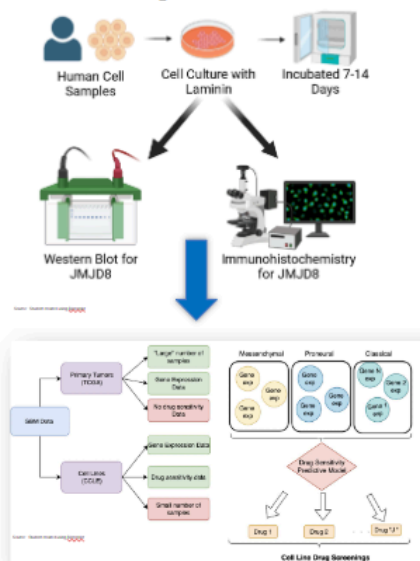
Methodology

Identifying Key Preclinical Drug Targets in Tunneling Nanotubes using Laser Capture Microdissection and Omics-based Analysis



Decoding the Proteomic Landscape of Tunneling Nanotubes using an Integrative Approach Combining Mechanistic Pathway Analysis and Literature Review

In-vitro Identification of Protein of Interest in Astrocytes cultured with GSCs using Western Blotting and Immunohistochemistry.



Sensitivity of Protein Targets to existing drugs using Machine Learning Models and Bayesian Network Analysis

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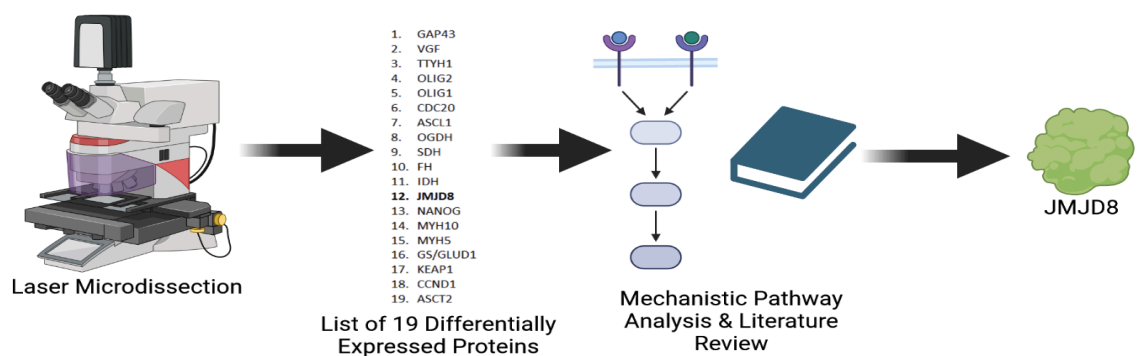
Results:

JMJD8 (Jumonji domain containing 8) was identified as a key protein of interest based on increased expression levels in TNTs and mechanistic pathway analysis.

To identify which proteins could be contributing to the transport of tumorigenic cargo in the TNTs in GBM, Leica laser microdissection was conducted to cut open the TNTs and analyze the proteins within these microfilaments using proteomics and transcriptomics approaches. The initial approach of identifying which protein targets to pursue was based on levels of expression of molecular targets (RNA and Protein) analyzed using the proteomics and

transcriptomics approaches. A set of 19 proteins were identified which had elevated protein and RNA expression levels. To identify which among these sets of proteins we could focus on, based on consultations with experts in the field, I determined that applying a mechanistic pathway analysis (Goldilocks method) would be the more appropriate approach to consider identifying a possible pre-clinical drug target. Mechanistic pathway analysis is a computational aided method which builds linkages between known molecular pathways and proteins. The pathway analysis was performed on each of the individual differentially expressed protein targets.

In addition to analyzing the pathways, literature review related to these proteins of interest narrowed down the protein target that warranted further investigation to be JMJD8 (Jumonji Domain-Containing protein 8) as many of the Jumonji domain containing proteins were mechanistically linked to cancer prognosis and treatment resistance as summarized by Manni et al., 2022 and Liang et al., 2022. Further analysis using Western Blots and Immunohistochemistry was done to confirm the presence of this protein of interest (JMJD8) in cells isolated from GBM autopsies and controls.



Source: Student created using Biorender

Fig 1. Proteomics and Transcriptomics analysis of Tnts reveal 19 differentially expressed proteins. Mechanistic pathway analysis and literature review was then employed to identify potential pre-clinical drug targets.

Tunneling Nanotubes are formed when GSCs from GBM autopsy tissue are cultured with treatment sensitive astrocytes.

Glioblastoma Stem Cells (GSCs) and Astrocytes obtained from human samples with differential growth characteristics are grown using recommended cell culture media. The cultured cells were incubated 7- 14 days to allow the Tunneling Nanotubes to form between the cells. We documented there is increased formation of Tunneling Nanotubes in cultures with GBM from tumors with aggressive growth kinetics. We further documented how frequently the cell counts in each of the individual cultures doubled and correlated the same with the number of TNTs observed in culture dishes using light microscopy. The cultures with shorter doubling times had a greater number of TNTs observed suggesting TNTs are impacting growth characteristics of the mixed GSC-Astrocyte cultures.

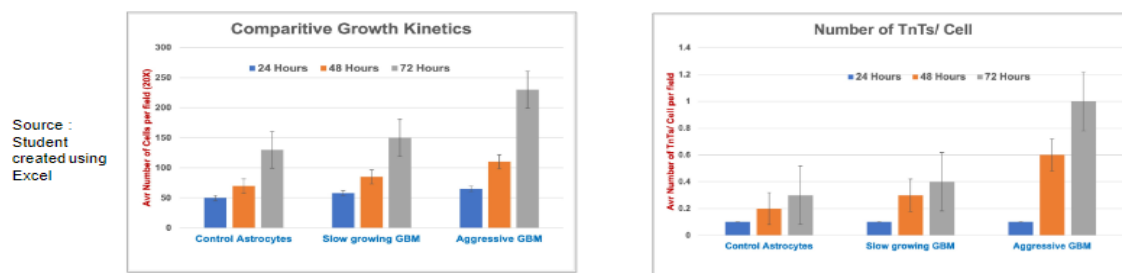
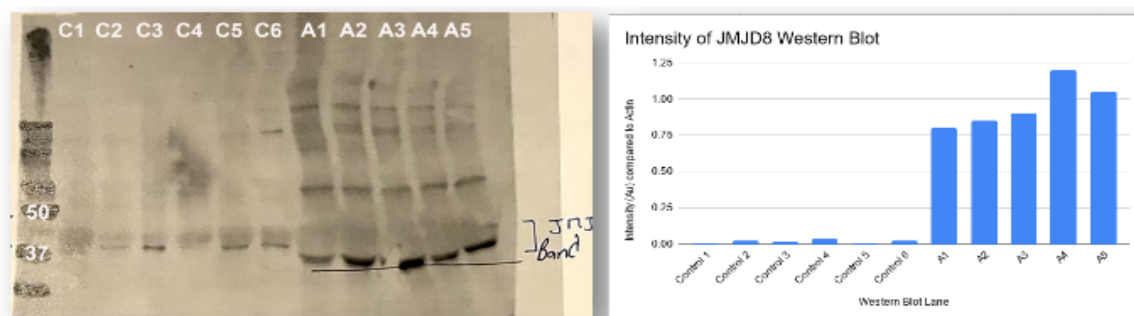


Fig 2. Comparative Growth Kinetics and Number of Tnts per cell in Control astrocytes and GBM cell lines with differential growth kinetics

JMJD8 expression is enhanced when GSCs and naive astrocytes are co-cultured.

To examine whether the protein of interest JMJD8 is expressed at high levels in astrocytes co-cultured with GSCs, Western blot was done using Anti-JMJD8 antibodies as previously described in the procedures section. Multiple samples of Astrocytes that were incubated with GSCs and without GSCs (controls) were examined. Western blot analysis revealed

significantly higher levels of expression of JMJD8 in samples that were incubated with GSCs in a tumorigenic environment. This observation suggests that the TNTs enable transfer of tumorigenic cargo from the GSCs to the naive astrocytes.

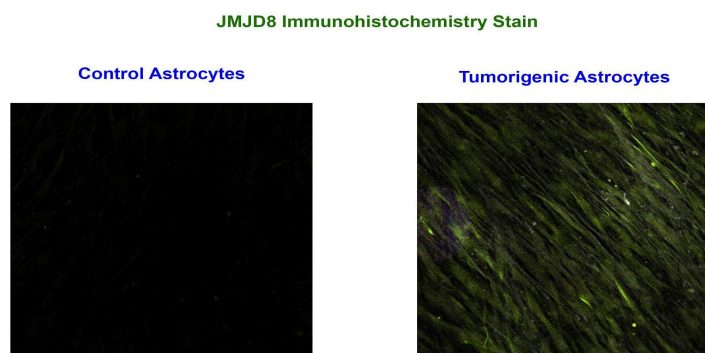


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Fig 3. A significantly higher JMJD8 expression revealed by Western blot in samples co-incubated with GSCs in tumorigenic environment, indicating TNT-mediated transfer of tumorigenic cargo.

Confirmation of increased JMJD8 expression using immunohistochemistry

Increased expression of JMJD8 was also confirmed using immunohistochemistry using JMJD8 specific antibodies tagged with Alexa Fluor 455 Dye that will make the proteins easily identifiable through the confocal fluorescence microscope. The astrocytes that were subjected to a tumorigenic environment had significantly higher levels of expression of JMJD8 compared to the naive astrocytes.

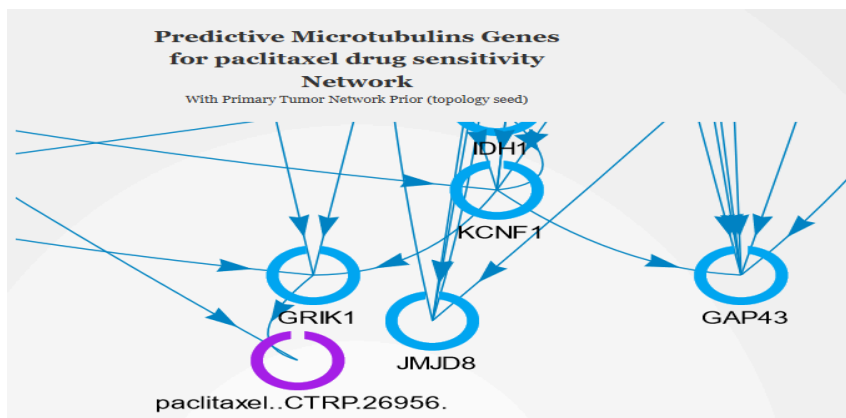


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Fig 4. Elevated expression of JMJD8 verified by immunohistochemistry in astrocytes exposed to tumorigenic GSC environment compared to naive astrocytes.

Computational methods to examine impact of existing chemotherapeutic agents on JMJD8 using the TCGA database.

To discover if any of the existing chemotherapeutic agents have an impact on JMJD8, data from the Tumor and Cancer Genomic Atlas (TCGA) was used and the impact of different drugs on mechanistic molecular pathways was analyzed using Bayesian network analysis. The bnviewer library made the visualization possible, while tidyverse and BSDA were used to format the data and conduct a multivariate analysis on the data provided. As part of this model, 3 key chemotherapy drugs were analyzed: Vinblastine, Cytochalasin, and Paclitaxel due to their role in prevention of cellular proliferation and cell to cell communication. While Vinblastine and Cytochalasin did not have any direct or indirect mechanistic impact on JMJD8 expression levels, Paclitaxel had an indirect effect on JMJD8 expression through pathways involving GRIK1, KCNF1 and NaNoG. This suggests a possible drug that could be used to prevent transport of tumorigenic cargo through TNTs is Paclitaxel. Experiments are underway to examine the impact of Paclitaxel on growth characteristics of GSCs and astrocytes isolated from GBM autopsy tissues using in-vitro approaches.



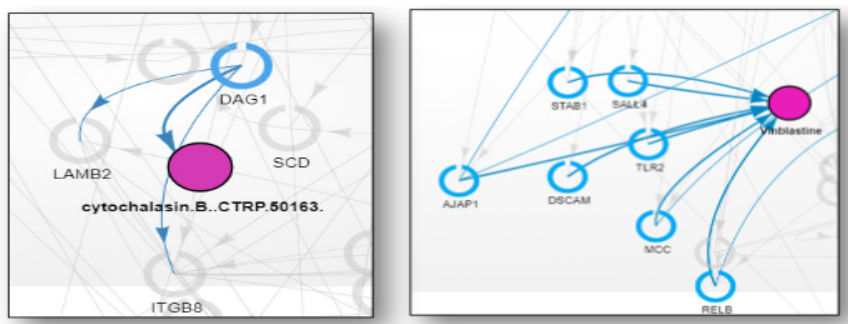
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Fig 5. Potential impact of repurposed drugs on JMJD8 expression analyzed via TCGA data; Paclitaxel affects expression indirectly via GRIK1, KCNF1, NaNoG pathways.

Reverse Learning using Bayesian Nets to identify intracellular drug targets for existing chemotherapeutic agents in GBM.

As Vinblastine and Cytochalasin did not have any direct or indirect mechanistic impact on JMJD8, I wanted to investigate if there could be other possible intracellular protein targets in GBM tumors that can be possibly targeted. Vinblastine and Cytochalasin are known microtubule inhibitors and would work to reduce the prevalence of TNTs in the tumor. To begin with, datasets for both Vinblastine and Cytochalasin on the TCGA database were combined using the splice tool in R. After combining the data together, the dataset was cleaned, and any empty values were omitted. The structured learning of the Bayesian Nets was initiated, and as the nets began to adapt and learn from the input data a visualization was built. The two datasets were incorporated one at a time and a blacklist was utilized once again to make sure the model was only using the data input. On completion, the bnviewer library was then utilized to illustrate the model with all nodes.

Based on the model, it can be determined that there were 5 different intracellular molecular targets present in GBM tumors which are significantly impacted by Cytochalasin and Vinblastine: SLC12A4 (Transport) for Cytochalasin, and AJAP1 (cell communication), DSCAM (Cell communication), MCC (differentiation), and RELB (Proliferation) for Vinblastine. Experiments are underway in the lab to analyze the levels of expression of these proteins in cell cultures that have been isolated from GBM autopsy tissue. If any of these molecular targets have altered expression levels in cells isolated from GBM tumors either Vinblastine and/or Cytochalasin can be used in in-vitro experiments to examine the impact on cellular proliferation and formation of TNTs.



Source: Student created using R studio

Fig 6: Five intracellular molecular targets impacted by Cytochalasin, Vinblastine in GBM tumors: SLC12A4 (Transport), AJAP1 (communication), DSCAM (communication), MCC (differentiation), RELB (proliferation).

Discussion & Conclusions:

Glioblastoma multiforme (GBM) is one of the most malignant types of central nervous system tumors and despite advances in treatment modalities, it remains largely incurable. According to the American Association for Neurosurgeons, GBM is the most common tumor that occurs in the brain, accounting for just under 50% of all brain tumors. Only 40% of patients survive the first year after diagnosis, and only 17% survive 2 years after diagnosis (Hanif et al. 2017). GBM is incredibly hard to treat, primarily due to the disease's ability to evade standard treatment methods such as chemotherapy, radiation, and surgery. The primary

goal of my research project was to identify preclinical molecular drug targets in GBM employing in-vitro aided computational approaches. To identify preclinical molecular drug targets, it is important to understand the mechanisms involved in evasion of cancer treatment and recurrence of the tumor and to research disease pathology, and tumor cell phenotype and potential to replicate. An emerging theory in the understanding of GBM disease pathology is the “Stem cell model” of GBM proliferation (Pinto et al. 2021). This model suggests that only a subset of cancer cells have the potential to indefinitely self-renew, initiate and maintain tumor growth along with facilitating other cells (such as astrocytes) to become resistant to chemotherapy and radiation (Valdebenito et al. 2021). Tunneling Nanotubes (TNTs) have recently been discovered as one of the mechanisms that the tumor stem cells use for the intracellular exchange of cellular components and proteins that confer the ability to evade treatments like chemotherapy. (Valdebenito et al. 2021).

The rationale for my project is to identify preclinical molecular targets in the TNTs that enable transfer of tumorigenic cargo between treatment resistant and sensitive cells isolated from GBM autopsy tissue and to explore the sensitivity of identified targets and associated proteins to existing chemotherapy agents and other approved drug candidates using advanced machine learning based techniques and data from the cancer genome atlas (TCGA) database. Analyzing the molecular targets began with culturing of GSCs with naive astrocytes to document the formation of TNTs followed by laser microdissection of TNTs to identify the protein targets expressed in the TNTs. Proteomics and transcriptomics of the TNTs helped in identification of the key proteins that were differentially expressed and mechanistic pathway analysis in conjunction with literature review narrowed down the focus to the protein target **JMJD8 (Jumonji domain containing 8)**.

Further analysis using Western Blots and Immunohistochemistry was done to confirm the presence of this protein of interest (JMJD8) in cells isolated from GBM autopsies and controls. Western blot analysis revealed significantly higher levels of expression of JMJD8

in naive astrocyte cells that were incubated with GSCs in a tumorigenic environment. Immunohistochemistry using JMJD8 specific antibodies tagged with Alexa Fluor 455 Dye confirmed the increased expression of JMJD8 in cells co-cultured in the tumorigenic environment. These results suggested JMJD8 can be a potential molecular drug target for treating resistant GBM tumors and the next step was to use computational aided analysis to find possible chemotherapeutic agents or other drugs that can target JMJD8. To discover if any of the existing chemotherapeutic agents have an impact on JMJD8, data from the Tumor and Cancer Genomic Atlas (TCGA) was used and the impact of different drugs on mechanistic molecular pathways was analyzed using Bayesian network analysis. The drug, Paclitaxel, had an indirect impact on expression of JMJD8 through pathways involving GRIK1, KCNF1 and NaNoG. This suggested a possible drug that could be used to prevent transport of tumorigenic cargo through TNTs and achieve GBM tumor remission is Paclitaxel. Further, reverse machine learning analysis using TCGA database information on GBM of other possible drugs revealed 5 molecular targets: SLC12A4 (Transport) for Cytochalasin, and AJAP1 (cell communication), DSCAM (Cell communication), MCC (differentiation), and RELB (Proliferation) for Vinblastine.

The goal of my research project was to identify molecular drug targets to tackle treatment resistant GBM tumors. Using innovative novel approaches involving both in-vitro cell culture and computational tools, I have identified JMJD8 as an important molecular target alongside a possible drug (Paclitaxel) that can be used to alter the expression of this protein. Further, applying the principle of Bayesian network analysis and data from the TCGA database, we have identified other possible intracellular targets that are susceptible to drugs such as Vinblastine and Cytochalasin. As mentioned earlier, Glioblastoma multiforme is one of the most malignant types of central nervous system tumors and these molecular drug targets that are identified in this project can make a significant difference in survival of patients who develop these malignancies.

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American Junior Academy of Science #3

Ashrita Gandhari - Minimizing In-Vitro Fertilization Failures by Utilizing Artificial Intelligence to Evaluate the Health of Human Embryos
Thomas Jefferson High School for Science and Technology

Minimizing In-Vitro Fertilization Failures by Utilizing Artificial Intelligence to Evaluate the Health of Human Embryos

The quality of the transferred embryo is the crucial factor that impacts the success of the in-vitro fertilization (IVF) treatment cycle. Embryologists and other related experts in the field are responsible for deciding which embryo should be chosen to continue in the IVF process. These clinicians are faced with a life-changing task that could potentially lead to failure of conception, and they should ensure their final diagnoses are accurate. Alternative tools used to make this paramount decision are limited, subjective, time-consuming, and extremely expensive. However, an embryologist's skills, coupled with the precision and accuracy of an automated evaluation system, could improve IVF success rates by ensuring consistent results. Employing modern technologies, such as artificial intelligence (AI), is the deciding factor between providing accurate or inaccurate results. This project, LetoHealth, utilizes prevalent convolutional neural network (CNN) architectures to distinguish embryo health and quality at 113 hours post insemination (hpi) on day 5 of culturation based on its morphology. In this study, I assessed ResNET-50, Xception, and custom-built multi-layered CNN architectures; Xception performed the best with a validation accuracy of 0.98, precision of 0.98, and a loss of 0.05 among these. In addition, LetoHealth includes a web-based evaluation tool built using the best-performed Xception model hosted on the cloud that embryologists and clinicians can access, producing instant results of embryo health.

INTRODUCTION

Approximately 48 million couples to 186 million individuals live with infertility around the world [1]. The birth of the first baby conceived using in vitro fertilization (IVF) occurred in the late 1970s[2]. Since then, there have been many advances in IVF. However, the journey to parenthood via IVF is prolonged, and emotionally and financially challenging for many infertile patients [3]. The current manual microscopic analysis of embryo selection is subject

to inconsistent embryo grading, and many unsuccessful IVF births have resulted in this [4]. Therefore, selecting suitable embryos to implant is extremely important, as this increases the chance of success, minimizes complications, and ensures the baby will be healthy.

With little to no new attention in the field, the success of IVF has remained static for over a decade, and future parents have had to deal with the repercussions of inaccurate embryonic diagnoses. Much research focuses on improving the current 30% success rate of IVF [3]. Artificial intelligence (AI) is a revolutionary technology that has been responsible for many other successes in the medical field [5]. These technologies have been gaining traction for their potential to improve outcomes concerning other pressing medical issues such as Alzheimer's disease, any type of cancer, diabetes, and much more. The application of AI and deep learning (DL) to the IVF diagnosis process could be a much-needed breakthrough for infertile parents [6].

Embryo transfers take place either at the cleavage stage which is 2-3 days after fertilization, or blastocyst stage which is 5-6 days after fertilization [7]. Therefore, the main objective of this study was to evaluate widely used CNN models using day 5 embryo (113 h post insemination) images in classifying embryos according to their morphological quality. Day 5 embryos were used for the network evaluation studies, emphasizing their significance to the field of embryology and since most published studies concentrate on this specific stage of embryo development [8].

The current study, LetoHealth, has evaluated popular CNN models such as Xception, ResNet-50, and multilayered CNN from scratch to identify healthy embryos with the highest chances of achieving a successful pregnancy. The models were tested by training embryo images from 113 hours of post-insemination (hpi). In our results, I could conclude that the Xception model performed the best in evaluating embryos based on their morphological quality, with an accuracy of around 0.98 and a loss of 0.05.

MATERIALS AND METHODS

Data Collection and Preparation

The retrospective image data used for this study were collected as part of routine clinical practice. These 2,440 de-identified and anonymous images of human embryos were obtained from Massachusetts General Hospital (MGH) fertility center using 3,469 recorded videos of embryos collected from 543 patients. These images were extracted at a specific time point of 113 hours post-insemination (hpi), and 5 days post laboratory culturation, and were categorized in 5 classes.

The images of human embryos in Fig 3.1.1 depict representation from each of the classes (1-5) of embryos. Fig 3.1.2 displays the split of each embryo class within the initial dataset, in the form of a bar graph.

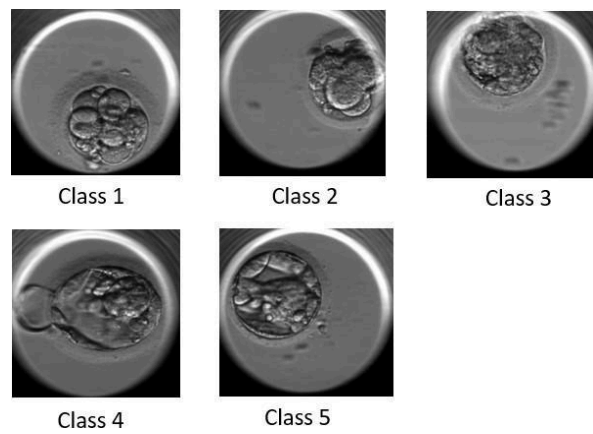
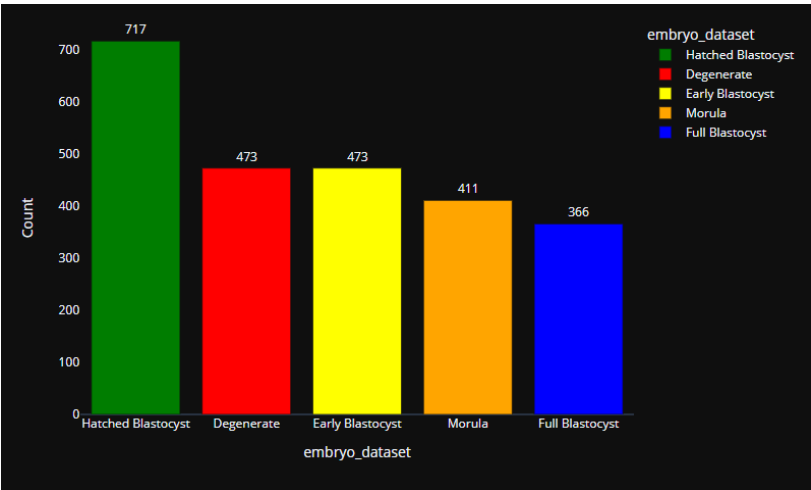


FIGURE 3.1.1
REPRESENTATIVE IMAGES FOR EACH CLASS OF EMBRYO. CLASS 1 - DEGENERATED OR ARRESTED EMBRYO. CLASS 2 - MORULA STAGE. CLASS 3 - EARLY BLASTOCYST STAGE. CLASS 4 - BLASTOCYST WITH BLASTOCOEL CAVITIES. CLASS 5 - HATCHING BLASTOCYST.

Table 3.1.2

THE DATA DISTRIBUTION OF THE HUMAN EMBRYO IMAGE DATASET. EACH BAR DISPLAYS A DIFFERENT CLASS OF EMBRYO IMAGES.



EVALUATION OF CNN ARCHITECTURES

Several CNN architectures were trained and tested in embryo assessments to determine the most suitable network for evaluating embryos based on their morphology. ResNET-50, and Xception architectures along with a 17-layer CNN were evaluated by training them on day-5 embryo images for classification. To assess various hyper-parameters and compare the performances of these models, I split the data into 65% for training, 10% for validation, and 25% for testing.

I. Xception

The Xception architecture pre-trained on ImageNet was used for this study with include top=False. The input size used for this model was 128 x 128 x 3. During the transfer learning process, I discarded the last fully connected layer of the original network and added a new fully connected layer with the SoftMax mathematical function, which classifies the features into the five classes listed above. This entire network was trained by optimizing categorical cross-entropy loss using a Nadam optimizer with a learning rate of 0.0001 and decay of 0.0001 for 113 hpi embryo classification. The network was trained over 25 epochs and achieved a loss of 0.0535, a validation accuracy of 0.98, and a precision of 0.98. A myriad of dropout layers was used to finetune the model and prevent overfitting to achieve the most optimal results.

II. ResNET-50

The second model, ResNET-50, was trained with Nadam optimizers and had the learning rates set to 0.0001. The corresponding decay was 0.0001 for every 50 epochs, and the batch size was

32. The input size of the embryo image used was 128x128x3 pixels. The base architecture of the ResNet-50 model was used along with an extra three, fully connected, layers. These extra layers had 512, 256, and 128 neurons between the ResNET-50 bottleneck and final classification layers, respectively. This model also had a dropout set at 0.5 utilizing Rectified Linear Unit (ReLU)

activation. LetoHealth's ResNET-50 model achieved a loss of 0.0992, a validation accuracy of 0.96, and a precision of 0.96.

III. Multi-layer CNN

The sequential 17-layered CNN used a learning rate of 0.0001 with a Nadam optimizer that had a decay of 0.0001 for every 100 epochs. The input size of the embryo image used was 256x256x3 pixels, and each image was convoluted through 16, 32, and 64 feature maps. This

was done using 3x3 filters with padding and ReLU activation. A dropout layer was also used with a dropout probability set at 0.2, along with a flattened layer connected to the hidden dense layers of 512, 256, and 128, connected to the 5-neuron output layer with SoftMax.

RESULTS

Proper feature learning and classification of categories using CNNs usually requires extensive amounts of annotated image data [9]. However, high-quality medical datasets are inadequate; therefore, I have transfer learned ResNET-50 and Xception over ImageNet weights and utilized data augmentation in addition to create further data. ResNET-50 and Xception were retrained using 1,647 embryo images, validated using 183, and tested using 610 embryo images recorded at 113 hpi. The same dataset was used to train a 17-layer CNN model.

I. Dual Learning Loss and Accuracy Curves

After evaluating these three models, the next step was to compare each model's results side-by-side to choose which one is most optimal for LetoHealth. Table 4.1 consists of model hyperparameters, validation accuracies and losses and displays Xception has superior validation accuracy and loss. Besides this, I created dual learning curves of loss and accuracy for all models using both the training and validation datasets. Figure 4.1.1 displays Xception model accuracy of

0.98 and loss of 0.05. Figure 4.1.2 displays ResNET-50 model accuracy of 0.96 and loss of 0.09. Figure 4.1.3 displays multi-layer CNN model accuracy of 0.71 and loss of 0.64.

After comparing each dual learning curve for the three models, I concluded that the Xception model performed the best out of the three. I observed that the Xception validation loss graph decreases to the point of stability and has a small gap with the training loss. This showed me that the Xception model was a good fit with a validation loss of 0.0535 and validation accuracy of

0.98. However, if this model were to be trained any further, it could lead to overfitting of the dataset.

Table 4.1

A SUMMARY OF EACH MODEL, THEIR HYPERPARAMETERS - LEARNING RATE DECAY,
VALIDATION LOSS, AND VALIDATION ACCURACY.

Model	Architecture	Learning Rate	Optimizer	Decay	Validation Loss	Validation Accuracy
Xception	Base Architecture + global average pooling	0.0001	Nadam	0.0001	0.0535	0.9832
ResNET-50	Base Architecture + dropout(0.5) + flatten + dense layers	0.0001	Nadam	0.0001	0.0992	0.9627
Multilayer CNN	3 layer3-3 + <u>maxpooling</u> + <u>flatten</u> + dense	0.0001	Nadam	0.0001	0.6462	0.7100

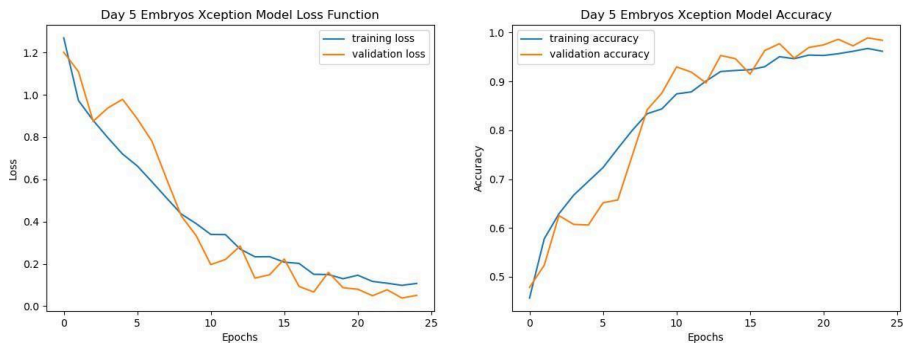


FIGURE 4.1.1

XCEPTION MODEL TRAINING AND VALIDATION LOSS AND ACCURACY LEARNING CURVES

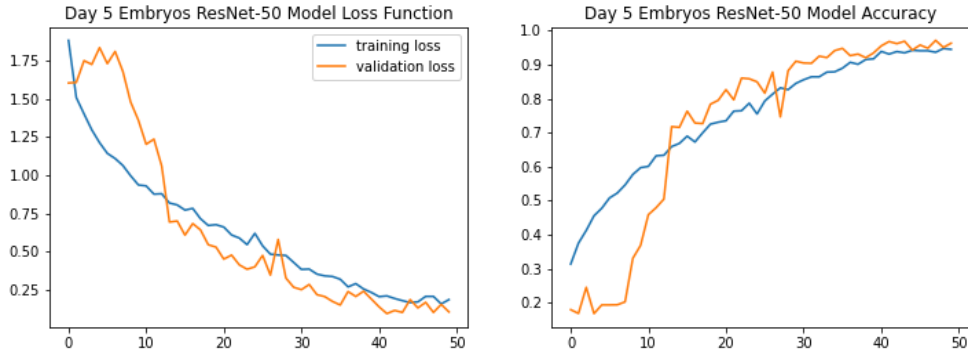


FIGURE 4.1.2

RESNET-50 MODEL TRAINING AND VALIDATION LOSS AND ACCURACY LEARNING CURVES

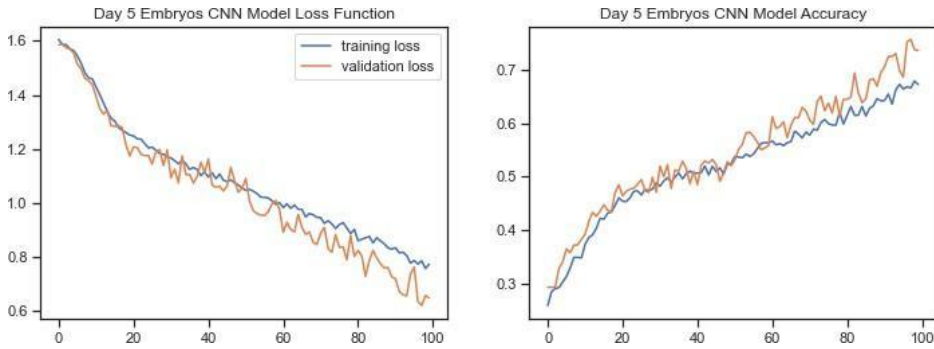


FIGURE 4.1.3

MULTI-LAYER CNN MODEL TRAINING AND VALIDATION LOSS AND ACCURACY LEARNING CURVES

II. *Confusion Matrices*

To further draw conclusions and make comparisons between these three models, I constructed confusion matrices for each of them. Confusion matrices allow us to display and visualize results for data analyses in an easily readable form [10]. Confusion matrices also provide a means of direct comparison that allows the user to draw conclusions from the data. The current study's confusion matrices showed which classes the model predicted correctly and which classes the model predicted incorrectly.

In the case of the Xception model, by summing the rows of the Xception confusion matrix, there were 118 class 1 images, 103 class 2 images, 118 class 3 images, 92 class 4 images, and

179 class 5 images. Out of all these 610 images, the Xception model accurately predicted 598 images, which is a 598/610 percent prediction accuracy. This yielded an accuracy of 0.98 and a precision of 0.98 as well.

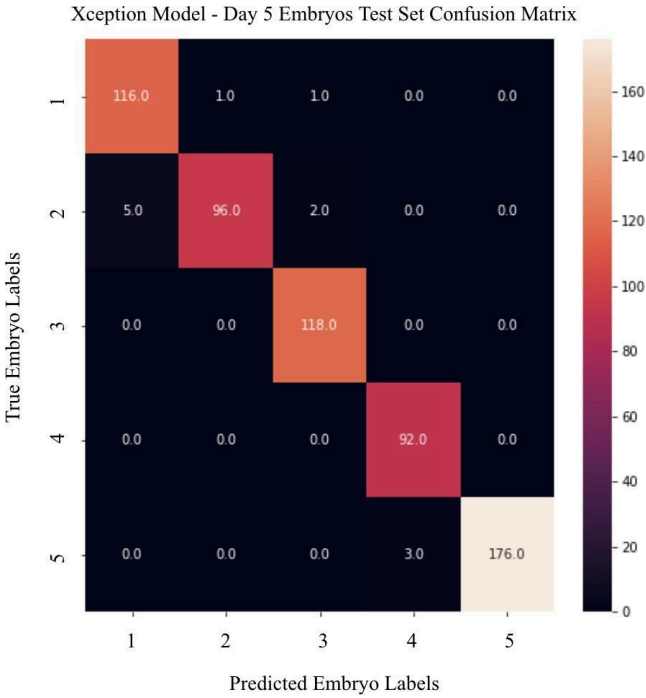


FIGURE 4.2.1
XCEPTION MODEL TEST CONFUSION MATRIX WITH AN ACCURACY OF 0.98.

Similarly, the ResNET-50 test confusion matrix shows an accuracy of 0.96 and a precision of 0.96.

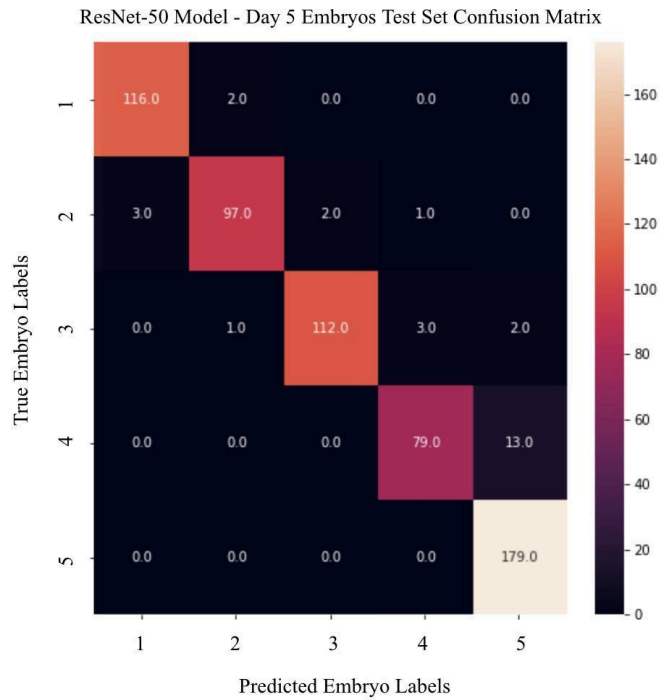


FIGURE 4.2.2

RESNET-50 MODEL TEST CONFUSION MATRIX WITH AN ACCURACY OF 0.96.

Lastly, the Multilayered CNN test confusion matrix shows an accuracy of 0.71 percent accuracy and a precision of 0.70.

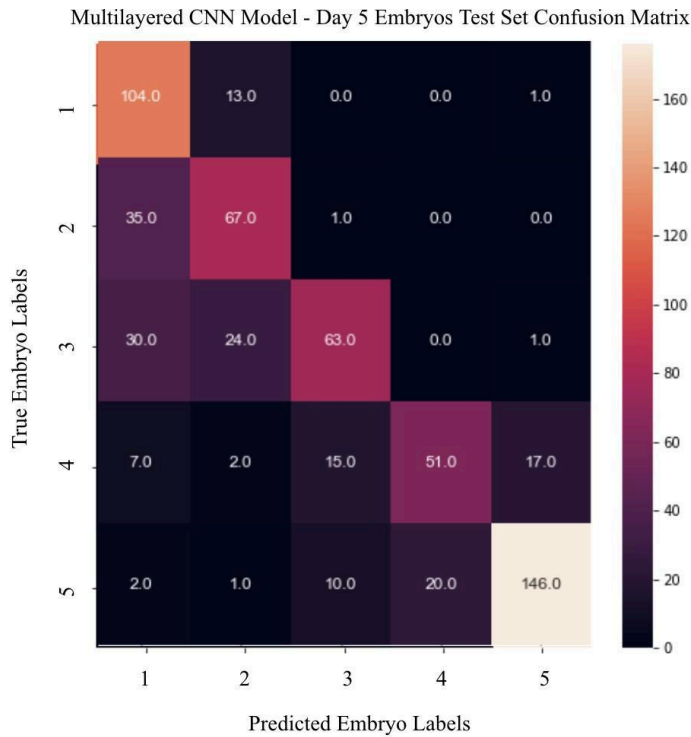


FIGURE 4.2.3
MULTILAYER CNN MODEL TEST CONFUSION MATRIX WITH AN ACCURACY OF 0.71.

With the newfound information that Xception is the most optimal model, LetoHealth plans on using this model to make all the diagnoses, as it provided the best results, with the highest accuracy and precision.

III. Test Accuracy Report

Figure 4.3 displays the Xception model's precision, recall, f1-score using the unseen test embryo images. The overall accuracy of the Xception model is 0.98.

	precision	recall	f1-score	# of unseen images
Class 1	0.96	0.98	0.97	118
Class 2	0.99	0.93	0.96	103
Class 3	0.98	1	0.99	118
Class 4	0.97	1	0.98	92
Class 5	1	0.98	0.99	179
accuracy				0.98 610
macro avg		0.98	0.98	0.98 610
weighted avg		0.98	0.98	0.98 610

FIGURE 4.3

XCEPTION MODEL TEST ACCURACY REPORT DISPLAYS ALL THE 5 CLASSES PRECISION, RECALL, F1-SCORE AND # OF TEST UNSEEN EMBRYO IMAGES. THE OVERALL ACCURACY IS 0.98.

IV. *Gradient-weighted Class Activation Mapping (Grad-CAM)*

Lastly, Grad-CAM [11] were computed to highlight the regions of interest using the test set of embryo images in the dataset. CAM was used for producing heat maps to highlight class-specific regions of images. These heatmaps are used to visualize which parts of a human embryo image the network model was looking at to classify the embryos [12]. As a result, the LetoHealth's Xception model was able to isolate embryos into clusters based on their specific morphological features. This distinction of important morphological features and unneeded parts of the image is crucial in the image classification process and is highlighted using heatmaps. The heatmaps were also extracted from the network to highlight the highest weighted features for the embryo images. The highlighted regions included regions of cellular fragmentation, blastomeres (in the cleavage stage embryos), cavitation, vacuoles, the inner cell mass (placenta) and trophectoderm.

Xception Day 5 Embryos Testset Images Heatmap Analysis

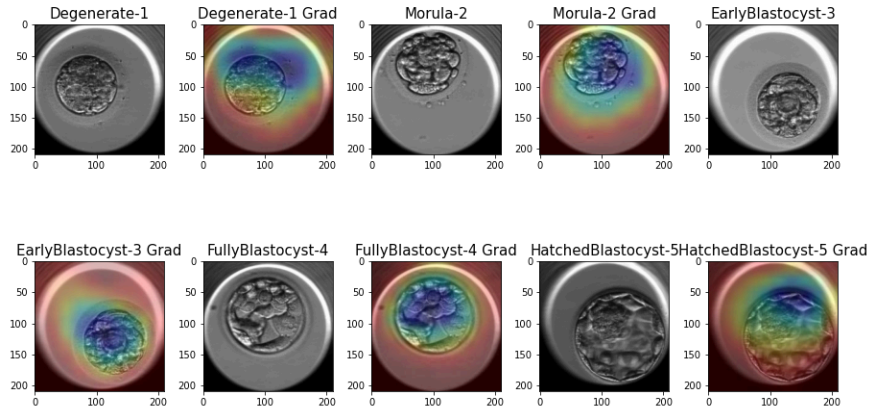


FIGURE 4.4

XCEPTION MODEL TEST EMBRYO IMAGES GRAD-CAM HEAT MAPS

LETOHEALTH WEB USER INTERFACE

To enhance accessibility to LetoHealth's human embryo classification system based on morphology, I have developed a web-based application hosted on cloud. This application enables embryologists and clinicians to analyze real-world clinical data with just an internet

connection. When preparing the user input, I employed the same strategies that were used in training the model. The Web user interface (UI) receives the user-uploaded human embryo image, resizes it to dimensions of 128 pixels x 128 pixels x 3 col or channels. Subsequently, the packaged LetoHealth Xception model processes the image, providing instant updates to the user interface with dynamic predictions of human embryo quality.

I want to leverage LetoHealth web-based UI application to collaborate with embryologists, facilitate communication and support IVF patients through stressful treatment cycles. LetoHealth instant automated 5-class classification performs with an accuracy of approximately 0.98, or 98%. While LetoHealth can serve as a valuable second opinion to verify embryologists' diagnoses, it's important to acknowledge that AI has inherent limitations and lacks the empathetic qualities that humans possess. Embryologists and clinicians should make the final decision using their own expertise in the field. Overall, I believe it is in the best interest of the healthcare industry to continue incorporating and exploring the use of AI in assisting regular clinical tasks.

STATISTICAL ANALYSIS

One of LetoHealth's goals was to evaluate the AI approach in classifying embryo images based on their morphological quality and compare them with the existing studies. When compared to 8 other similar deep learning models used in similar studies in the field, LetoHealth’s model had a more impressive improvement in Area Under Curve (AUC), as shown in image 10.1.

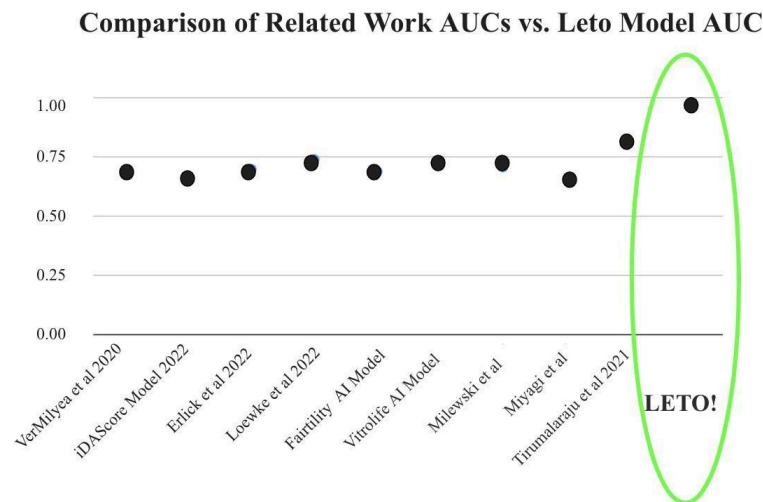


FIGURE 5.1
LETOHEALTH DISPLAYS A SIGNIFICANT IMPROVEMENT IN AREA UNDER CURVE (AUC)
SCORE COMPARED TO 8 OTHER SIMILAR
DL MODEL SCORES.

In addition to displaying a higher AUC, LetoHealth also displays a significant improvement in test accuracy scores when compared to these same 8 DL model scores. This is shown in image 5.2.

Comparison of Related Work Test Accuracies vs. Leto Model

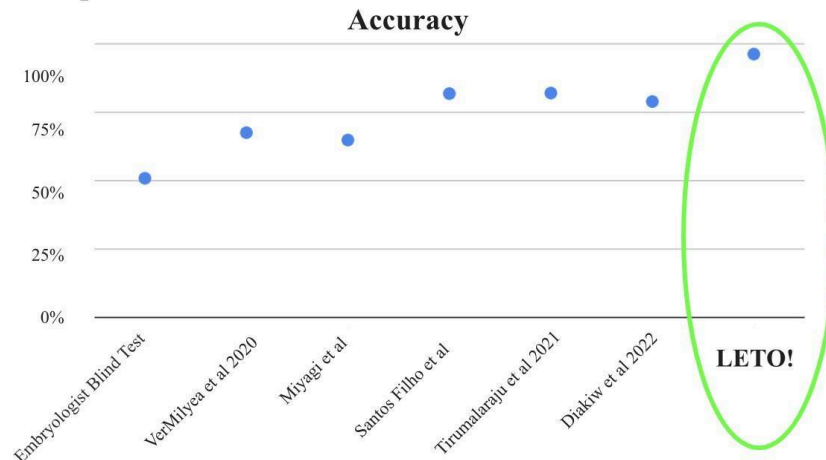


FIGURE 5.2
LETOHEALTH DISPLAYS A SIGNIFICANT IMPROVEMENT IN TEST ACCURACY SCORES
COMPARED TO 8 OTHER SIMILAR DL MODEL SCORES.

CONCLUSION

After evaluating each CNN architecture, Xception model's validation loss and accuracy reflect that LetoHealth is an accurate and reliable model that can be trusted to serve as a second opinion to embryologists in the healthcare field. The final Xception model correctly identified more than 98% of the day-5 embryos based on their morphology, which is of critical importance, clinically, when identifying embryos suited for transfer. This accuracy is almost a 40-45% increase in AUC when compared to other leading clinical tools in the field, such as Vitrolife or Fairtility, signifying LetoHealth's efficiency in distinguishing between the positive and negative classes.

LetoHealth effectively demonstrates how AI can be utilized in the fields of medicine and healthcare, particularly in assisting the IVF embryo transfer selection procedure. Future parents undergoing IVF treatment can significantly benefit from modern advancements in

machine learning, as demonstrated by LetoHealth. LetoHealth web UI can deliver the results in real-time and allows faster diagnosis, which ultimately contributes significantly towards the IVF treatment plan of patients. However, Leto's 5-class classification accuracy should be taken as a second opinion to embryologists as AI has limitations, and the clinicians should make the final decision.

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American Junior Academy of Science #4

Siruthya Morishetty – An Empirical Analysis of the Existence of Greenwashing in the Wider US Market: A Test on the Efficacy of ESG Scores.
Individual

An Empirical Analysis of the Existence of Greenwashing in the Wider US Market: A Test on the Efficacy of ESG Scores

Abstract

The purpose of this study was to investigate the relationship between a company's Environmental, Social, and Governance Score (ESG Score), a widely accepted method of a firm's perceived environmental sustainability, and each firm's corresponding greenhouse gas emissions. This provides an empirical analysis of the existence of greenwashing in the stock market as well as the effectiveness of ESG scores as a reliable market tool. Using S&P Global ESG Scores and Trucost Environmental data from Wharton Research Data Services database, linear univariate, multivariate, and fixed effect regression models were employed to derive the relationship between a company's average annual ESG score and the natural log of a company's annual greenhouse gas emissions cost. It was hypothesized that there would exist a strong negative correlation

between a firm's ESG score and greenhouse gas emissions cost, as a company with worse environmental policies would have a greater cost associated with negative emissions. However, there existed a weak positive correlation between a firm's ESG score and greenhouse gas emissions, indicating that a firm's overall ESG score does not well-represent a company's negative greenhouse gas emissions. In order to more comprehensively evaluate the sustainability of a firm, a more expansive variety of company-assessing tools and indexes should be taken into consideration, as a firm's overall ESG scores does not thoroughly assess every portion of a firm's environmental policies. This calls for improved mechanisms of measuring the environmental impact of a firm in order to encompass the full effect of negative emissions in a company's environmental rating and diminish the existence of greenwashing in the wider US market.

Introduction

In recent years, global concern has underscored the detrimental effects of climate change, specifically in regard to rising temperatures, negative environmental impacts, health risks, and socio-economic disruptions. The growth of sustainable finance has summoned the attention of investors, policymakers, and civil servants to deliver financial objectives, alleviate societal concerns, and promote sustainability. The economic importance of Environmental, Social, and Governance (ESG) considerations, specifically environmental sustainability, has become increasingly important to investors, companies, and policymakers. Climate change poses a long-term risk to various industries, and firms that embrace ESG principles can lead themselves to effective long-term valuations. Internationally, companies that adhere to ESG standards are more globally competitive, innovative, and more likely to manage risk effectively, overall increasing the sustainability of companies long-term.

The rise of socially responsible investing can be traced back to the Socially Responsible Investing Movement of the 1960s and 1970s, where investors had arguably just begun to

consider social and environmental factors in their investments. More recently, the UN Principles for Responsible Investment (PRI) of 2006 launched a framework for responsible investing that encourages investors and institutions to factor ESG principles into the process of

decision-making. Most importantly in 2015, the adoption of the COP21 Paris Agreement and the introduction of the Sustainable Development Goals by the UN marked a steep incline in the acknowledgement of environmental issues and climate change in investment-strategies, increasing global commitment to address climate change. Presently, ESG reporting standards such as the Global Reporting Initiative (GRI) and the Sustainability Accounting Standards Board (SASB) has provided firms and investors with standardized methods of evaluating their ESG initiative, but there exists discrepancies on which ESG providers curate scores for which firms.

Environmental, Social, and Governance Scores (ESG Scores) are crucial tools for investors to analyze a company's sustainability and have been applied to companies representing around 80% of market capitalization in 2020 (Boffo et al., 2020). The scores range from 0-100, with 50 representing a relatively poor score and 70 representing a relatively good score. In order to align capital flow with sustainability, a number of indexes, instruments, ratings, and principles have emerged to guide the risks and opportunities of a climate-focused firm. The environmental "E" pillar of ESG scores is increasingly employed as a tool to align investors with

environmentally focused firms with goals of long-term sustainability, with the main objective being driving down greenhouse gas emissions.

Greenhouse gas (GHG) emissions include carbon dioxide, methane, nitrous oxide, and various industrial gasses. Their emissions contribute to a phenomenon known as the greenhouse gas effect, a driver of global warming and climate change. The dependent variable is the GHG Cost, which is the external cost of direct and indirect greenhouse gas emissions that estimates the value of a service based on the cost of damage that results from its loss. It is based on the assumption that the cost of maintaining an environmental

benefit is a reasonable estimate of its value.

As of 2021, two-thirds of S&P 500 companies have set targets to reduce greenhouse gas emissions, but only 9% of S&P 500 companies have implemented or plan on implementing science-based targets, which create a clearer pathway to decarbonization (Karim et al., 2021).

Although 354 of the S&P 500 companies have emissions policies, only 245 have specific reduction targets (Karim et al., 2021). An increase in ESG-based investing has led firms to generally pursue a more favorable score, but the gap between proposed and effective climate objectives, and how they are allocated into the score, remains wide. In a recent meta-analysis, the researchers found that 58% of papers had a positive relationship between ESG and financial performance, 8% had a negative relationship, 13% had no relationship, and 21% had mixed results (Whelan et al., 2021). This indicates that there still exists considerable disagreement about the accuracy and validity of ESG data.

Greenwashing is the act of misleading consumers of a firm's environmental benefits, a practice that can have detrimental impacts on consumer satisfaction, as well as brand, brand reputation, and consumer loyalty. The existence of greenwashing in the large-scale market threatens the validity of ESG scores and ESG reporting. Greenwashing behavior in ESG dimensions is present globally, but can be deterred by scrutiny from independent directors, institutional investors, influential public interests, and by being cross listed (Yu et al., 2020).

Furthermore, the environmental pillar of ESG scoring may not necessarily be effective for investors seeking to better align their portfolios with low carbon economies, as environmental scores often do not align with carbon emissions exposures and can be difficult to interpret due to the multitude of diverse metrics on environmental factors (Boffo et al., 2020). For some ESG rating providers, high E scores positively correlate with high carbon emissions and for other ESG

rating providers, the opposite is true. It is asserted that the E score does not prioritize carbon emissions in its range of environmental metrics (Boffo et al., 2020).

Companies that report ESG scores are generally seen as more sustainable in the long-term and globally competitive, which could increase a firm's revenue. Corporate transparency of environmental disclosure plays an important role in incurring revenue. Measured by return on assets and market-to-book value ratio, voluntary environmental disclosure strongly and positively influences current financial performance in regard to companies with green patents; however, environmental disclosure acts as a diminishing factor of return on capital employed (Hoang et al., 2020). Corporate transparency in regard to environmental standards is also linked to better stock market performance (Hoang et al., 2020). Furthermore, there exists a positive relationship between internal governance, capital expenditure and carbon emission disclosure in their analysis, displaying the need for more governmental regulations on the environmental practices of firms (Karim et al., 2021). In addition, investing in green innovation has a positive correlation with a reduction in carbon emissions and an improvement in financial performance (Khalil et al., 2021).

The primary objective of this study was to empirically assess the relationship between ESG scores and GHG emissions cost, thereby testing the efficacy of ESG scores, and to investigate the presence or absence of greenwashing in the stock market at large. The independent variable/regressor was the ESG scores of companies in the S&P 500, and the dependent variable/regressand was the direct and indirect cost of greenhouse gas emissions. The direct and indirect cost of greenhouse gas emissions is calculated by assessing the damage caused by the loss of an environmental benefit, like fewer greenhouse gasses. By doing so, the value can be estimated by assessing how much it would cost to fix the problems incurred by losing the environmental benefit.

Long-term sustainability and profitability in a globally competitive market has become increasingly relevant to investors as they assess a firm for risk factors and growth opportunities. The risk of greenwashing in the large-scale market stands as a threat to investors who use ESG scores as their primary tool for evaluating the sustainability of a company. It is posited that higher ESG scores of companies in the dataset positively

correlates with a higher greenhouse gas cost, as a firms' cost of maintaining an environmental benefit should be directly correlated with their acquired ESG rating.

Methods and Materials

For each company in the dataset, the average annual ESG score served as the independent variable, and the dependent variable was the absolute greenhouse gas emissions cost. The data was obtained using the University of Pennsylvania's Wharton Research Data Services (WRDS). Within the database, the values of the ESG scores were acquired from S&P Global Market Intelligence using S&P Global ESG Scores, which is a part of the S&P Global Corporate Sustainability Assessment (CSA). Such environmental, social, and governance scores assess a company based on the S&P Global Corporate Sustainability Assessment (CSA) process and publicly available sources, providing a lens into a company's business value drivers, including growth, profitability, capital efficiency, and risk exposure. The value of the absolute cost of a company's greenhouse gas emissions was also taken from S&P Global Market Intelligence, using Trucost Environmental data, which measures the environmental impact of over 15,000 companies across key dimensions to assess environmental costs, identify and manage environmental and climate risk, and conduct peer and portfolio analysis from a climate and environmental perspective.

The data is representative of companies in the S&P 500, as the index is a widely-accepted indicator of the United States' economic health and stock market performance. The dataset consists of ESG data and greenhouse gas emissions cost values from eight years, from 2013 to 2020. The raw ESG scores for a given company each year were averaged, as each company reported scores at varying time intervals and frequencies (ranging anywhere from once to three times a year), in order to obtain the final independent variable of the "average_annual_score" of each company. The dependent variable was also curated by averaging all greenhouse gas cost values for a company in a given year.

In addition, the average annual GHG Cost was divided by the employee size of each company, which was obtained from a public S&P data source, in order to control for the size of the company. Lastly, with the dependent variable controlled for the size of the company, the natural log of the company-size controlled variable was taken, establishing the final dependent variable of “lnCost.”

In addition to the independent and dependent variables, the dataset included each reported company’s Institution ID, Ticker, Period End Date, Company Name, Company Type, Simple Industry, Incorporation Country, Country, Incorporation State, State, and the Year Founded from the S&P Global Market database accessed through WRDS. In addition, a variable

denoting a company’s age was curated by subtracting the Year when the data was reported and the Year Founded. As a binary/categorical variable, the variable Public was also generated, which displays 1 if the company is public and 0 if the ticker represents the investment “arm” of a company or the investment sector. The SimplyIndustry_encoded variable, which took the raw SimpleIndustry data and was encoded for the purpose of analysis, had a minimum of 1 and a maximum of 70.

Prior to analysis, the data was manually cleaned for each year. Since the S&P Global Market Database is a global database, not only reporting US-based companies, some tickers represent international companies that share the same ticker as US-based companies. In order to ensure that each ticker represented the US-based company in the S&P 500 and not an international company with an identical ticker, the dataset was analyzed and filtered manually to ensure that each company was in fact a part of the S&P 500 database. This resulted in a varying number of companies reported for years ranging from 2013-2020.

Figure 1: Number of ESG Data Tickers Kept and Removed.

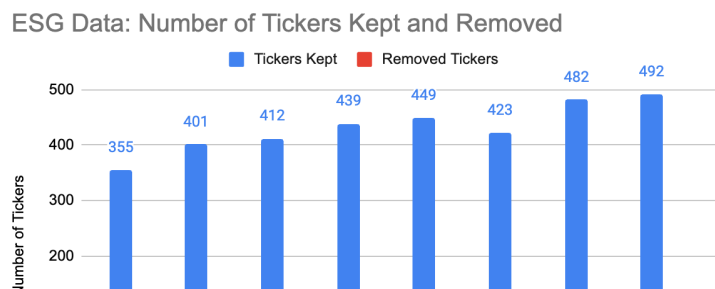
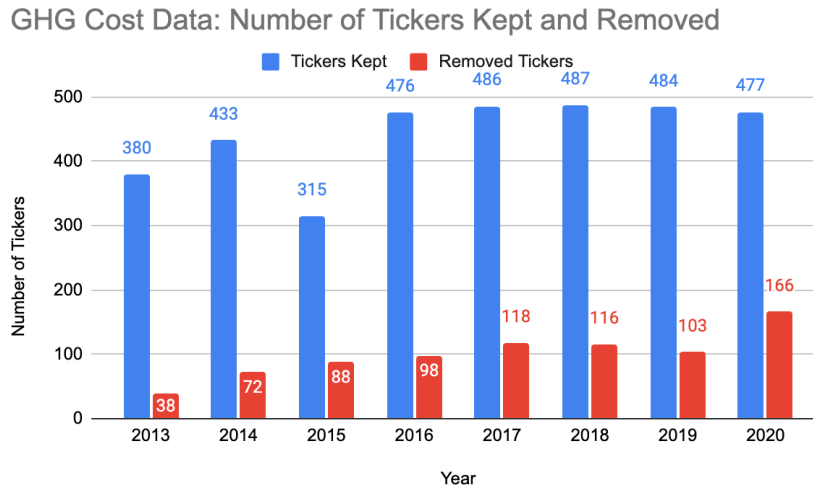


Figure 2: Number of GHG Cost Data Tickers Kept and Removed.



Once the data was collected and cleaned, the datasets were exported from Excel to Stata/BE 18.0, where the data analysis and regression analysis was performed. Both datasets, one containing ESG data and the other containing GHG data, were merged using each company’s Institution ID. On the appended file, regression commands were run. This includes a univariate regression analysis with only the average ESG score values and the natural log of the average greenhouse gas emissions cost values. A multivariate regression was run next with additional control variables, including a company’s age, whether a company’s overall standing or the standing of a company’s “arm” is being evaluated, and the industry type. The same regression was run with heteroskedasticity controls. A two-way fixed effect model was also run using each company’s average ESG score value, the ln of a company’s average greenhouse gas emissions cost, Institution ID, and year. The same two-way fixed model was run again but with clustered standard errors at the company level.

Results

In the dataset, the average annual ESG Score, the independent variable, ranged from 10 to 91, and the average was 43.104 with a standard deviation of 17.173. The lnCost, the

dependent variable, ranged from -14.560 to 1.972 with a mean of -5.958 and a standard deviation of 2.011. The variable of Simple_Industry, which ranged from 1-70, obtained a mean of 32.801 with a standard deviation of 19.784. For any given year, the ESG score values and GHG Cost values varied significantly, as each company was unique to itself.

Figure 3: Distribution of Average Annual ESG Score Values in 2020.

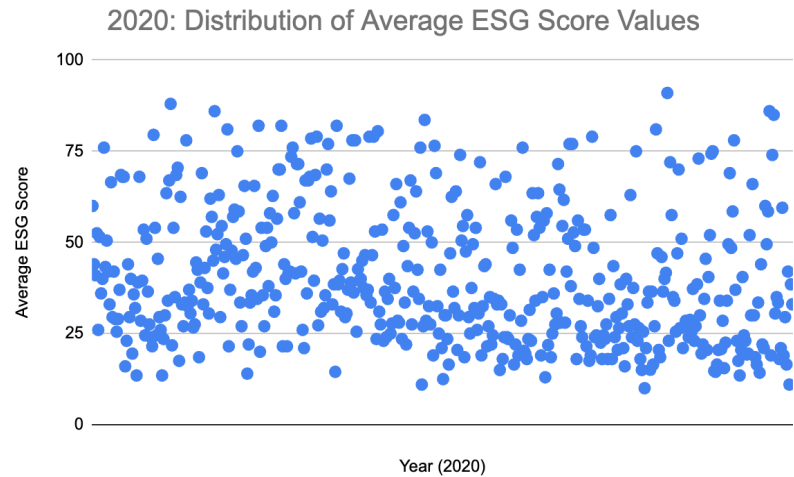
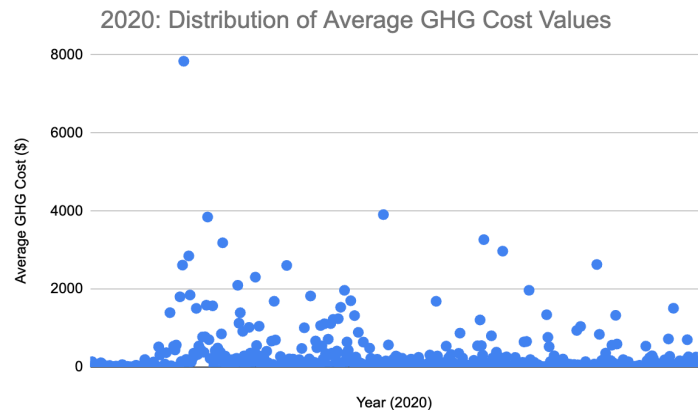


Figure 4: Distribution of Average GHG Cost Data Values in 2020.



It was hypothesized that a company’s ESG score is negatively related to its greenhouse gas emissions cost, demonstrating that a lower the cost associated with greenhouse gas emissions correlates to a higher ESG score. Five regression models were conducted, including a univariate regression, multivariate regression, a multivariate regression adjusted for heteroskedasticity, a two-way fixed effect model, and a two-way fixed effect

model adjusted for heteroskedasticity.

According to the univariate regression model, holding all else constant, a one-point increase of a company's ESG score is associated with a \$0.02094 increase in a company's GHG cost at the statistically significant 5% level ($p < 0.05$). The multivariate regression model, both adjusted for heteroskedasticity and not, indicated that a one point increase in a company's ESG score leads to a \$0.0034943 increase in their GHG cost at the 1% level ($p < 0.01$). Lastly, a one-point increase in a company's average annual ESG score is associated with a \$0.0019942 increase in the same

company's GHG cost at a statistically significant level of 2% ($p < 0.02$), according to the the two-way fixed effect model both adjusted for heteroskedasticity and not. However, prior to controlling the dependent variable for the size of the firm, a one-point increase in a company's ESG score led to a \$1.7843 increase in a company GHG Cost at the statistically significant level of 5% ($p < 0.05$), indicating a strong positive correlation between the two variables. Such a strong correlation did not exist once the dependent variable was controlled for size.

Figure 5: Regression Models.

$$1. \quad \ln(\text{GHG\_cost}) = b_0 + b_1 \times \text{average\_annual\_score}$$

$$2. \quad \ln(\text{GHG\_cost}) = b_0 + b_1 \times \text{average\_annual\_score} + b_2 \times \text{company\_age} + b_3 \times \text{public} +$$

$$\sum_i b_i \times \text{industry\_type}_i$$

$$3. \quad \ln(\text{GHG\_cost}) = b_0 + b_1 \times \text{average\_annual\_score} + b_2 \times \text{company\_age} + b_3 \times \text{public} +$$

$$\sum_i b_i \times \text{industry\_type}_i$$

$$4. \quad \ln(\text{GHG\_cost}) = b_0 + b_1 \times \text{average\_annual\_score} + \sum_i b_i \times \text{Institution\_ID}_i + \sum_j b_j \times \text{year}_j$$

$$5. \quad \ln(\text{GHG\_cost}) = b_0 + b_1 \times \text{average\_annual\_score} + \sum_i b_i \times \text{Institution\_ID}_i + \sum_j b_j \times \text{year}_j$$

This shows that a company's ESG score and GHG cost have a small positive correlation, meaning that a company's ESG score is not an effective indicator of a company's greenhouse gas emissions and how negative outputs cost the company. Although greenwashing may not directly be present in the market, ESG scores provide investors with false confidence as an "all-encompassing" signal of whether or not a company is sustainable. A company can have a significant amount of negative outputs, such as large greenhouse gas emissions, but still have a high ESG score due to favorable long-term policies and company-wide standards. ESG scores do not effectively consider all factors when determining the score for the "E" pillar (Environment), oftentimes fabricating a false positive to investors, officials, and the general public. Although ESG scores take into account a company's Social and Governance abilities well, the "E" pillar does not well-represent negative emissions and outputs. Therefore, an ESG score as the sole tool for determining a company's environmental policies, is not effective and can lead to misleading interpretations. For investors assessing companies in the S&P 500, this poses a threat to investors who rely on ESG scores for ESG-based investing to guide their policies. In addition, upon conducting an empirical analysis of companies in the S&P 500, there exists the possibility of greenwashing existing in the wider US market. This calls into question the significance and impactfulness of ESG-investing as a widely-accepted practice.

Discussions and Conclusions

This study aimed to primarily explore the relationship between S&P 500 companies' ESG score and their greenhouse gas emissions cost, demonstrating an empirical analysis of the impact of an important environmental indicator on the company's overall Environmental, Social, and Governance score, as an analysis of the wider US market. It was found that a company's GHG cost was positively associated with its ESG score in a

small magnitude, showing that although the two are positively correlated, affirming the hypothesis, the environmental impact and economic impact of greenhouse gas emissions may not be at the forefront of ESG score calculations. This highlights the need for additional indicators and methods of measuring the environmental impact of companies. In order to be useful, “E” (Environment) scores should align with both a company’s financial and environmental materiality in a transparent manner, allowing investors to be clear on what factors go into determining an ESG score. There exists no universal, standardized formula for calculating ESG scores, and discrepancies on score calculations due to the factors of determining ESG scores can serve as barriers to investors receiving accurate data. For instance, a company that excels in risk management and renewable transition plans, despite poor performance on emissions metrics, could receive a high ESG, and E, score (Boffo et al., 2020).

In order to reduce the risk of greenwashing and to help investors distinguish the meaning behind an E score, the disparities in underlying metrics should be made clear, specifically to better address reporting on low-carbon efforts and climate-based transitions of various companies.

Without accounting for the size of the company, results display a positive correlation with the “E” scores for two out of three providers, when carbon emissions were associated with a company’s “E” score, indicating that higher rated ESG companies, on average, pollute more in

terms of a gross output of carbon dioxide (Boffo et al., 2020). An inverse relationship for one out of three providers existed, holding the opposite to be true (Boffo et al., 2020). However, after accounting for the size of the company through company revenues, CO₂ emissions were found not to be correlated to E pillar scores (Boffo et al., 2020). However, there was a positive correlation between transition policies adopted and the E pillar score for all three ESG score providers, illustrating how long-term policies are better reflected in ESG score ratings, and specifically “E” pillar scores, as opposed to specific negative outputs, such as greenhouse gas emissions like carbon. Long-term

policies, as opposed to company outputs, are more likely to be the primary drivers of high “E” pillar scores.

Furthermore, a firm’s combined ESG score, social score, and Governance score all have highly significant positive relationships between the firm’s ESG score and firm value, but a firm’s individual Environment score has no significant relationship with firm value (Aydoğmuş et al., 2022). This establishes that simply looking at the combined score can mislead investors, as the Environmental score can be overpowered by the Social and Governance scores. Therefore, the E score in its current form could potentially be an ineffective tool for analyzing a firm’s carbon emissions and footprint. This calls for firms to report different ranges of metrics of data, as opposed to potentially misleading scores to further affirm a company’s ‘green’ practices and agenda. Greater transparency and compliance of firms can lead to more effective and honest ESG reporting.

As with green bonds, there are no extant principles or formal standards that are widely disclosed to construct the “E” pillar; rather, the “E” pillar is subject to various different underlying metrics, oftentimes not made transparent to an investor, for determining the score (Hoang, 2022). With confounding variables such as the score provider and the underlying metrics that determine an “E” pillar score, there is potential for greenwashing in the market at large, where companies that do not pursue low greenhouse gas emissions policies receive high E scores contingent upon the provider and underlying metrics. This leads to companies who have garnered a high “E” pillar score to benefit from investor trust and greater capital but not to face scrutiny over their lack of policies addressing negative outputs.

This analysis raises skepticism on the effectiveness and practicality of the application of ESG scores, specifically in relation to the “E” pillar, and the usefulness of ESG score metrics on the investment process in order to create investment portfolios aligned with low-greenhouse gas

strategies. Due to the low correlation between “E” pillar scores and greenhouse gas emissions, the “E” pillar of ESG scores on its own is not an appropriate tool for

indicating the low emission metrics of companies for investors. Instead, “E” pillar scores are better markers of long-term transition strategies, despite debate still remaining on the effectiveness of such strategies and the adoption of such policies.

For future study, the relationship between a company’s “E” pillar score, as opposed to the whole score value, and greenhouse gas emissions cost, can be investigated. In addition, a company’s ESG score can be associated with other negative environmental outputs, including water and waste, to further distinguish the underlying factors that go into determining an ESG score. Associating firm value and profitability with a company’s ESG score could also contribute to assessing the efficacy of ESG scores.

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Appendix

Figure 6: Split of Company Types in 2020 Dataset.

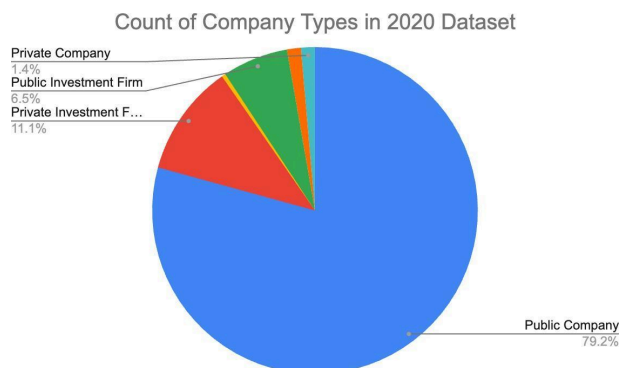


Figure 7: Split of Industry Types for Companies in the 2020 Dataset.

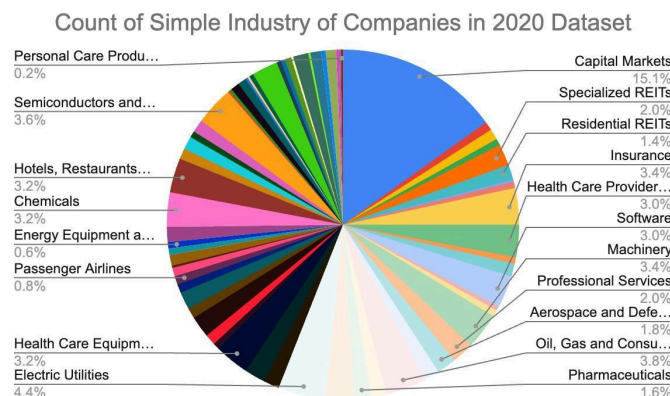


Table 1: Summary Statistics.

Variable		Obs	Mean	Std. Dev.	Min	Max
average_annu		3,911	43.10382	17.17292	10	91
lnCost		3,312	-5.957957	2.010658	-14.55902	1.971716
SimpleIndust ry_encoded		4,465	32.80134	19.78416	1	70
Public		4,549	.8085293	.3935018	0	1

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Ertle Thompson Memorial Endowment Award

Rania Lateef - Rhythms and Blues: Examining Potential Health Hazards of Blue Light-induced Circadian Disruption in *Drosophila melanogaster*.
Governor's School @ Innovation Park

R. Dean Decker Honorarium Award

Alexis Patanarut
Governor's School @ Innovation Park

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Debra Peterman
Benton Middle School

Franklin D. Kizer Professional Development Stipend

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